3 HOT MIX ASPHALT PLANT OPERATIONS

Effect of Plant Type on HMA Properties

Batch/Wet Wash
Batch/Baghouse
Drum/Wet Wash
Drum/Baghouse

Aggregate Blending

Design Mix Formula
Method for Combining Aggregates
Trial and Error Method
Troubleshooting Hints

Plant Inspection and Scale Check

Batch Plant
Drum Plant

Plant Calibration

Batch Plant
Drum Plant

Plant Troubleshooting

CHAPTER THREE:
HOT MIX ASPHALT PLANT OPERATIONS

A HMA plant is an assembly of mechanical and electronic equipment where aggregates are blended, heated, dried and mixed with binder to produce HMA meeting specified requirements. The plant may be stationary (located at a permanent location) or portable (moved from contract to contract). There are numerous types of plants, including batch plants, continuous mix plants, parallel-flow drum plants, counter flow drum plants, and double barrel drum plants to name a few. In general, however, the majority of plants may be categorized as either a batch plant (Figure 3-1), or a drum mix plant (Figure 3-2) and the information presented in this chapter covers these two types of plants.

In the batch-type mixing plant, hot aggregate and binder are added in designated amounts to make up one batch. After mixing, the HMA is discharged from the pugmill in one batch.

In the drum-type mixing plant, the aggregate is dried, heated, and mixed with the binder in the drum.

Regardless of the type of mixing plant, the basic purpose is the same. That purpose is to produce a HMA containing proportions of binder and aggregate that meet all of the specification requirements.

SAFETY

The Technician is required to always be safety-conscious and alert for potential dangers to personnel and property. Safety considerations are very important.

Dust is particularly hazardous. Dust is not only a threat to lungs and eyes, but may contribute to poor visibility, especially when trucks, front-end loaders, or other equipment are working around the stockpiles or cold bins. Reduced visibility in work traffic is a prime cause of accidents.

Noise may be a double hazard. Noise is harmful to hearing and may distract workers' awareness of moving equipment or other dangers.

Moving belts transporting aggregates and belts to motors and sprocket and chain drives are also hazardous. All pulleys, belts and drive mechanisms are required to be covered or otherwise protected. Loose clothing that may get caught in machinery is never worn at a plant.

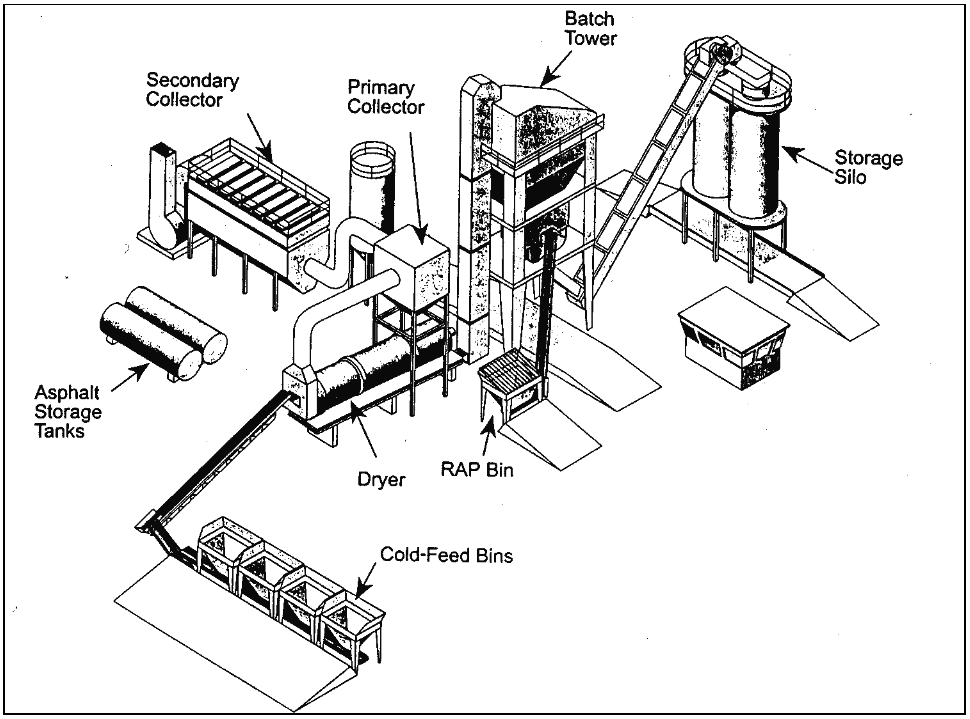

Figure 3-1. Typical Batch Plant

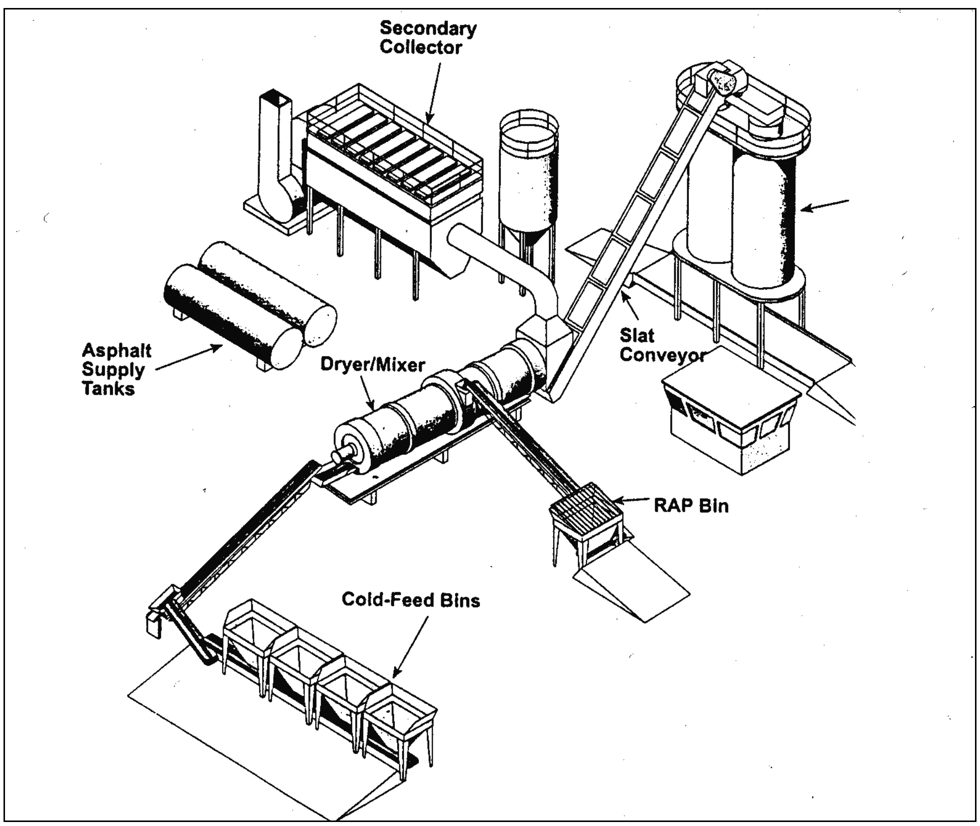

Figure 3-2. Typical Drum Plant

Good housekeeping is essential for plant safety. The plant and yard are required to be kept free of loose wires or lines, pipes, hoses, or other obstacles. High voltage lines, field connections, and wet ground surfaces are other hazards to the Technician. Any loose connections, frayed insulation or improperly grounded equipment are required to be reported immediately.

Plant workers are not allowed to work on cold bins while the plant is in operation. No one may walk or stand on the aggregates in the bins or on the bunkers over the feeder gate openings.

Burner flames and high temperatures around plant dryers are obvious hazards. Control valves that may be operated from a safe distance are required to be installed on all fuel lines. Flame safety devices also are required to be installed on all fuel lines. Smoking is not permitted near binder or fuel storage tanks. Leaks in oil heating lines and steam lines or jacketing on the binder distribution lines are dangerous. Safety valves are required to be installed in all steam lines, and be in working order. Screens, barrier guards, and shields as protection from steam, hot binder, hot surfaces, and similar dangers are required to be used.

When handling heated binder, chemical goggles or a face-shield are required. All shirt collars are required to be worn closed and cuffs buttoned at the wrist. Gloves with gauntlets that extend up the arm are required to be worn loosely so the Technician may flip them off easily if covered with hot binder. Pants without cuffs are required to be extended over boot tops.

The Technician is required to exercise extreme care when climbing around the screen deck, inspecting the screens and hot bins, or collecting hot bin samples. Covered or protected ladders or stairways to provide safe access to all parts of the plant are required to be provided. All stairs and platforms are required to have secure handrails. All workers around the plant are required to always wear a hard hat when not under cover.

Truck traffic patterns are planned with both safety and convenience in mind. Trucks entering the plant to pick up a load of HMA do not cross the path of loaded trucks leaving the plant. Also trucks should not have to back up.

SIMILAR OPERATIONS OF BATCH AND DRUM PLANTS

Certain plant operations are common to both the batch plant and drum mix plants. These operations include:

1) Cold aggregate storage and feeding

2) Dust control and collection

3) Mix storage

Also common to all plants is the importance of uniformity and balance, both in materials used and in plant operations. Uniformity encompasses uniformity of materials, uniformity of material proportioning, and continuous, uniform operation of all plant components. Changes in material characteristics, proportions, and intermittent stops and starts in plant operations make producing a HMA meeting Specifications extremely difficult.

Balance requires careful coordination of all elements of production. Balancing material quantities to plant production, and balancing plant production and pavement placing operations guarantee a continuous, uniform production and placement effort.

Uniformity and balance are best ensured by careful preparation. Materials are required to be sampled and tested and plant components carefully inspected and calibrated before production begins.

COLD AGGREGATE STORAGE AND FEEDING

The cold aggregate feed is the first major component of the mixing plant. The cold feeder may be charged by one or a combination of three methods:

1) Open top bins with several compartments. Materials are usually fed by a front-end loader

2) Tunnels under stockpiles separated by bulkheads. Materials are stockpiled over the tunnel by belt conveyor, or front-end loader

3) Bunker or large bins. Materials are usually fed by trucks, car unloaders, or bottom dump freight cars emptying directly into the bunkers

When charging the cold bins (Figure 3-3), segregation and degradation of the aggregate are problems that may occur. These problems may be prevented by taking the same precautions outlined for proper stockpiling. Enough materials are required to be maintained in all bins to provide a constant and uniform flow.

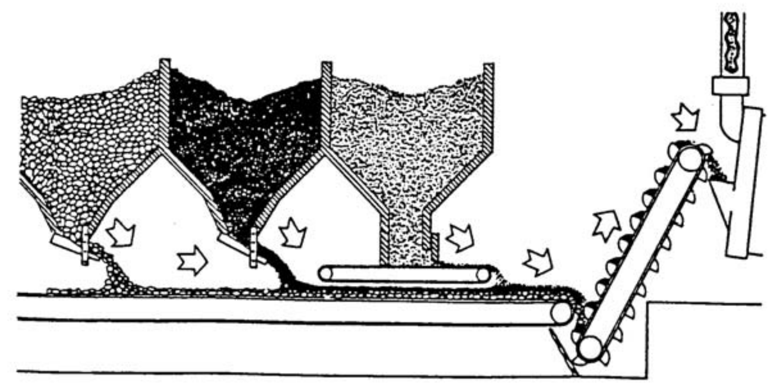

Figure 3-3. Typical Three Bin Cold Feed System

When a front-end loader is used to charge the bins, the operator should not pick up material from the storage stockpile at ground level. The scoop is held high enough above the ground to prevent contamination.

When trucks are used to charge the bins, the aggregate is deposited directly above the feeder.

When the stockpile is replenished by overhead belts or elevated conveyors, the free falling materials is controlled by baffles.

Aggregate feeder units are located beneath storage bins or stockpiles, or in positions that ensure a uniform flow of aggregates.

Openings located at the bottom of the bins deposit the different aggregates on a belt conveyor, and/or bucketlines, which carry the aggregates to the dryer. Feeder controls regulate the amount of aggregate flowing from each bin, thereby providing a continuous, uniform flow of properly-graded aggregate to the plant.

There are several different types of cold feeders. Among the most common are: (A) continuous belt type, and (B) vibratory type. Each is illustrated in Figure 3-4.

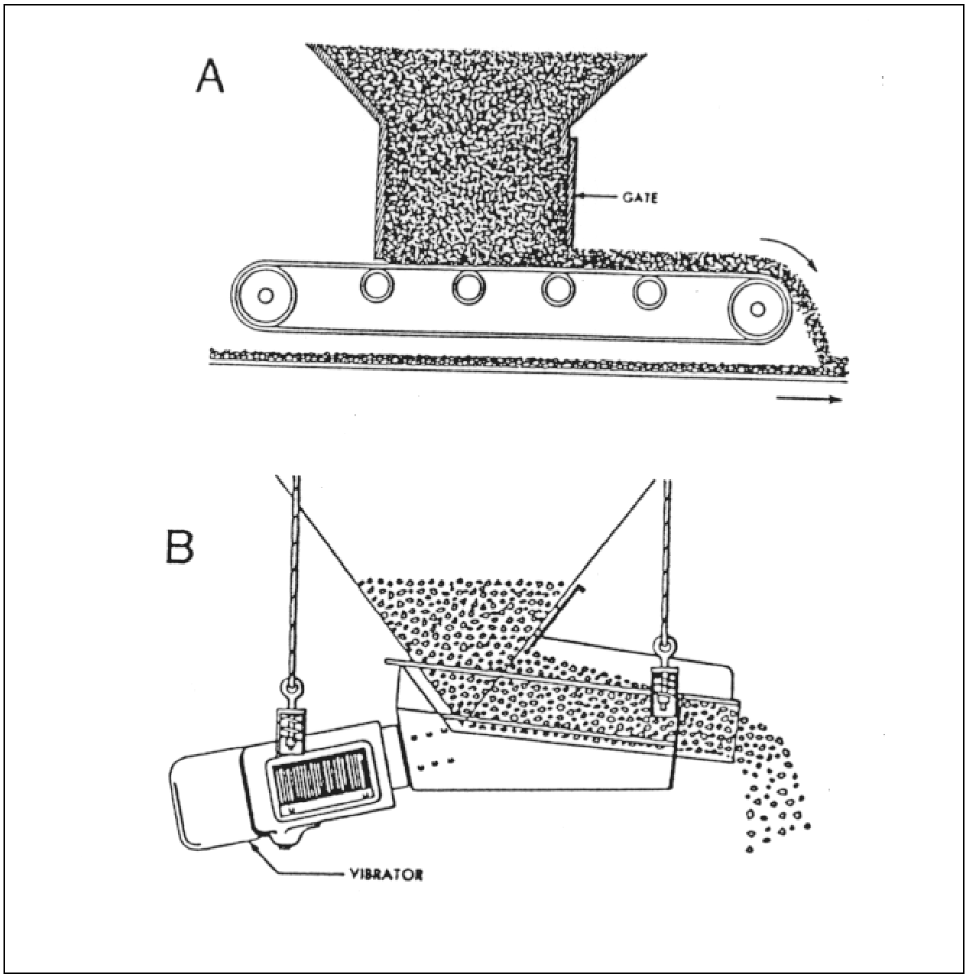

Figure 3-4. Typical Types of Cold Feed Systems:
A. Continuous Belt Feeder B. Vibratory Feeder

Using either system, the key element is how to control or regulate the flow of material from each bin. Every manufacturer has a different control method. Typical control variations are:

1) Gate opening
   a. Fixed
   b. Adjustable

2) Belt or vibrator
   a. One speed (on or off)
   b. Adjustable speed

The most common configuration is the adjustable gate with either an adjustable belt speed or vibrator.

Ensuring Proper Feeder Functions

Because a uniform flow of proper-sized aggregates is important to HMA production, the Technician is required to check before and during production to be certain that the feeder system is functioning properly. Conditions that help ensure proper feeder functions include:

1) Correct sizes of aggregates in stockpiles and cold bins
2) No segregation of aggregates
3) No intermixing of aggregate stockpiles
4) Accurately calibrated, set, and secured feeder gates
5) No obstruction in feeder gates or in cold bins
6) Correct speed control settings

Calibrating and Setting Feeders

The cold aggregate feeder is calibrated, set, and secured to ensure a uniform flow of aggregate. This calibration is the responsibility of the Producer.

The feeder is calibrated for each type and size of aggregate. Manufacturers often furnish approximate calibrations for their equipment, but the only accurate way to set a cold feed is to prepare a calibration chart for each of the aggregates to be used in the HMA. The Technician is required to examine the calibration charts of the cold feed systems to be aware of the production rate settings and how adjustments are made during production.

Calibration is simply determining the "Flow Rate" of a material graphed against the "Control" used by the particular system. Each material is calibrated for three to four control settings spanning the working production range anticipated for the material.

Control Setting

Each manufacturer has a method to control the flow of material from the cold feeds. The variable speed short belt feeder under each cold feed is the most common. The operator may adjust the RPM of the belt from the control room. Therefore, control is expressed as RPM or a percentage of the belt's total speed potential. (Figure 3-4 (A)).

This same concept is used with vibrating units (Figure 3-4 (B)). The vibrator may be adjusted from the control room and expressed as a percent of maximum vibration potential.

Adjustable gates are employed on most cold feeds. The gate height is measured by the height of the opening. This gate height is required to not change when using the variable speed control. The adjustable gate may be the control when the vibrator or belt feeders are set at one speed.

There may be variations and modifications of these concepts. Each plant is unique; however, the plants are required to have some means to control the cold feeder. The system is required to be completely understood and controlled in a positive way to provide a uniform flow of material.

Flow Rate

Flow rate may be determined by a variety of methods that are basically pre-determined by the configuration of the plant. The most common and accurate method of determining flow rate is to physically weigh the material delivered at a specific control setting over a measured period of time. A divert chute on the intake of the dryer is the simplest, most accurate, and quickest method to do the calibration. Material may be weighed on a weigh bridge, if available, or completely processed through the plant and weighed on the plant scales. The flow rate is then converted to tons per hour. Moisture content is required to be considered in this procedure.

The degree of accuracy is only as good as the method used to determine the flow rate for each control setting. Therefore, the larger the sample measured, the more accurate the data received. Using an entire truck load of material provides dependable numbers.

Calibration Chart

After understanding the plant "Control" system and determining the best method to obtain a "Flow Rate", a calibration is required to be done. This process determines a flow rate at four different control settings for each cold feed. The process may be time consuming but the benefits are worth much more than the time spent. Figure 3-5 illustrates a typical calibration chart of each bin. After multiple calculations have been done for each bin used during production, the calibration chart is prepared. On the chart, control settings are plotted on a horizontal scale, and the flow rate is plotted on the vertical scale.

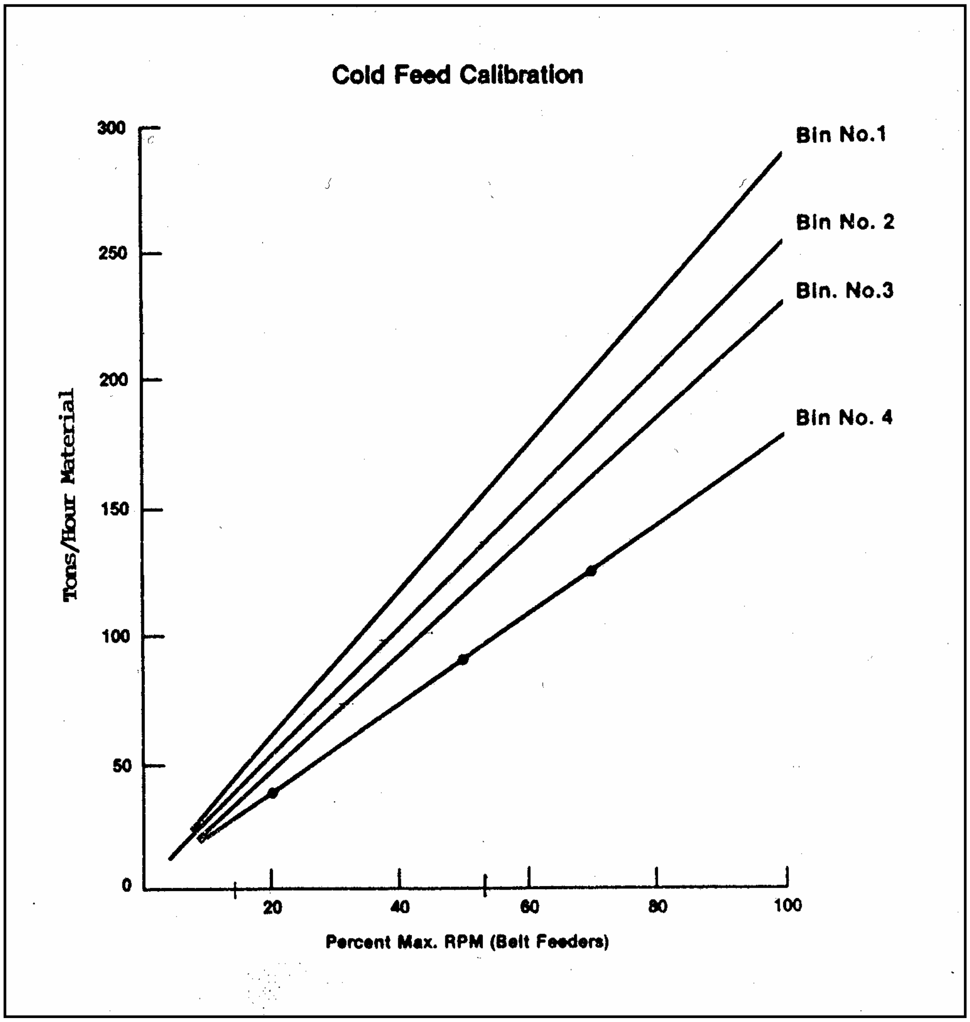

Figure 3-5. Calibration Chart

An example of determining the control settings for each cold feed using the calibration chart in Figure 3-6 is as follows:

1) Mix design criteria

Coarse Aggregate------------------------ 20 % (Cold Feed #1)
Intermediate Coarse Aggregate-------- 40 % (Cold Feed #2)
Fine Aggregate-------------------------- 30 % (Cold Feed #3)
Filler-------------------------------------- 10 % (Cold Feed #4)
Binder Content----------------------------5.0 %

2) Flow Rate Per Cold Feed

Q = T B P = Tons Per Hour

Q = Required Flow Rate per Bin (t/h)
T = Plant's Mix Production Rate (t/h)
B = % of Agg. in Mix (as decimal)
P = % by Weight of Total Mix (as decimal)

Plant Production of 350 t/h

Q (Cold Feed #1) = 350 x .95 x .20 = 66.5 t/h
Q (Cold Feed #2) = 350 x .95 x .40 = 133 t/h
Q (Cold Feed #3) = 350 x .95 x .30 = 99.8 t/h
Q (Cold Feed #4) = 350 x .95 x .10 = 33.2 t/h

3) Use the calibration chart to determine the control settings for each cold feed by locating the production rate for each cold feed on the vertical scale, moving horizontally to the appropriate control line and then vertically down to locate the control setting. (Figure 3-6) The approximate bin settings are:

Bin 1 = 23 %
Bin 2 = 53 %
Bin 3 = 43 %
Bin 4 = 18 %

By making these determinations, the discharge rate of each cold feed supplies a balanced flow of material. This balance is critical for a drum plant and provides a uniform flow of material across the batch plant screening unit to maintain uniform hot bin levels.

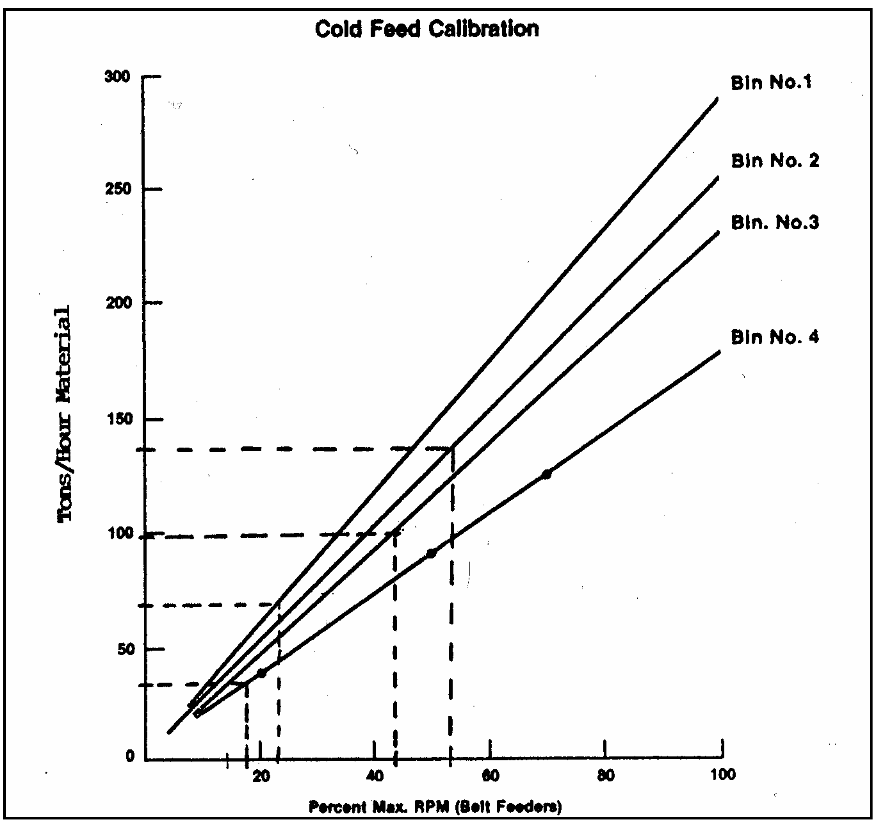

Figure 3-6. Calibration Chart

For larger production plants, more than one bin is required to be calibrated for each material. This back-up cold feed calibration allows continuation of production if a cold feed bin fails mechanically.

Another common practice for large production rates is to use two cold feeders to supply the same size of material. This practice allows for slower machinery rates, and tends to reduce segregation.

DUST CONTROL AND COLLECTION SYSTEMS

Enforcement of air pollution regulations or codes is usually done by the local pollution agency. However, since the dust control system is integrated with plant operation, the Technician is required to at least be aware of the controls and equipment necessary to meet these standards. The Technician is required to also be aware of how this equipment may affect HMA properties.

Mixing plant manufacturers recognize the problem of air pollution and have developed equipment that restricts the escape of pollutants from the plants. Even so, during the operation of a plant, some gaseous and particulate pollutants may escape into the air. These pollutants are required to be limited to meet established clean air regulations. The Producer is required to be familiar with the state and local laws concerning air pollution.

Air pollution control codes and regulations affecting plants normally include a requirement for stack emissions. The standard visual method uses a chart for grading the density of smoke. The chart illustrates the colors and transparency of various densities of smoke. Checks on emissions are made by matching the color and density of the exhaust plume just above the plant stack to one of the areas on the chart. The visual method does not accurately determine the amount of polluting material being released because black smoke appears denser than white dust. Consequently, more accurate electronic opacity meters, that use photoelectric cells to measure the passage of light, are replacing the opacity charts.

More definitive standards are based on the quantity of particulates coming from the stack. The most common requirement sets an upper limit on the mass of the particles being released as compared to the volume of gas released with them. Other standards relate the quantity of particulates emitted to the mass of the material being produced.

A major air pollution concern at a plant is the combustion unit. Dirty, clogged burners and improper air-fuel mixtures result in excessive smoke and other undesirable combustion products. Continual close attention to the cleanliness and adjustment of the burners and accessory equipment is important.

Another source of air pollution at a plant is aggregate dust. Dust emissions are greatest from the plant rotary dryer. Dust collectors commonly are used here to meet anti-air pollution requirements. Three types of dust collectors are commonly used to capture the dust from the dryer; centrifugal dust collectors, wet scrubbers, and baghouses (fabric filters). When the aggregate is especially dusty, two or more of these devices may need to be used in sequence. If the dust system returns the material to the plant, the return system is required to be calibrated.

Some of the dust emitted from a plant is fugitive dust. This is dust escaping from parts of the plant other than the primary dust collectors. A scheduled maintenance program is required to keep fugitive dust to a minimum.

Centrifugal Dust Collectors

Centrifugal dust collectors (cyclone type collectors) operate on the principle of centrifugal separation. The exhaust from the top of the dryer draws the smoke and fine materials into the cyclone where they are spiraled within the centrifuge (Figure 3-7). Larger particles hit the outside wall and drop to the bottom of the cyclone, and dust and smoke are discharged through the top of the collector. The fines at the bottom of the cyclone are collected by a dust-return auger and may be returned to the plant or wasted.

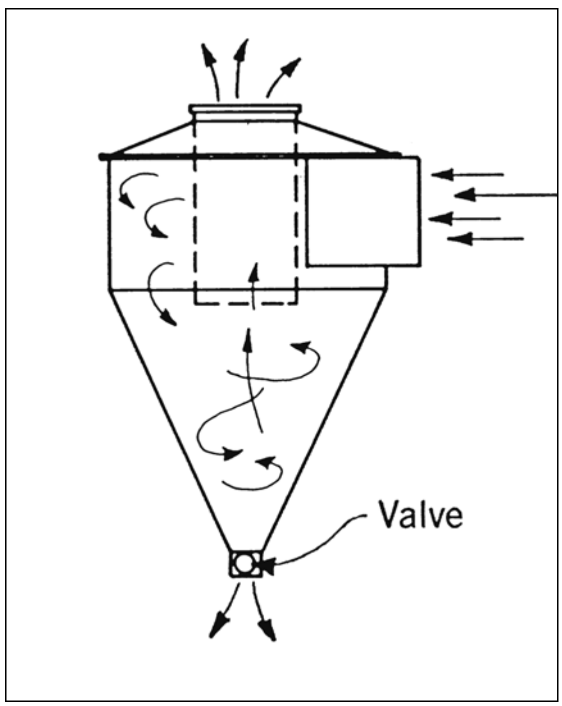

Figure 3-7. Cyclone Dust Collector

Centrifugal dust collectors have been the most common type used, especially in rural areas. However, under today's more stringent pollution laws, the centrifugal dust collectors are usually used in combination with either a wet scrubber or a baghouse.

Wet Scrubbers

The purpose of a wet scrubber (Figure 3-8) is to entrap dust particles in water droplets and remove the particles from the exhaust gases. This is done by breaking up the water into small droplets and bringing those droplets into direct contact with the dust-laden gases. As the figure illustrates, gases from the dryer are introduced into a chamber through one inlet, while water is sprayed into the chamber from nozzles around the periphery.

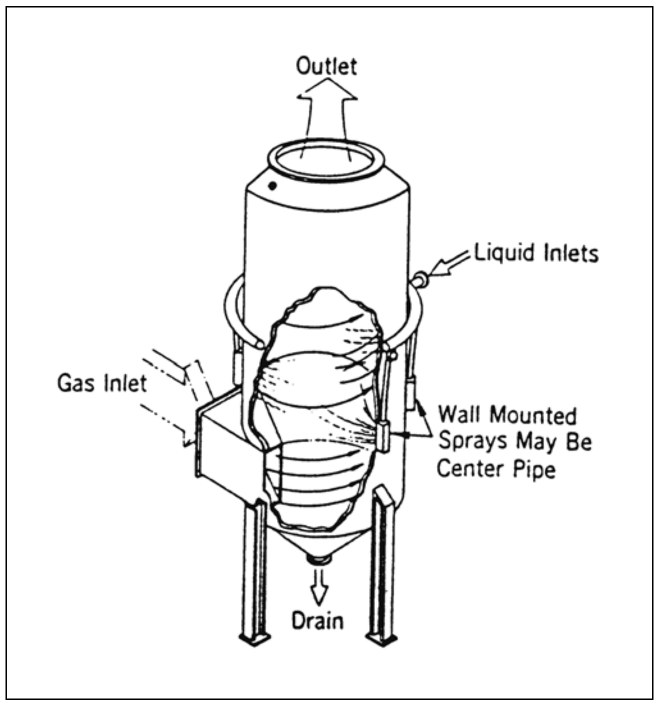

Figure 3-8. Typical Wet Scrubber

Wet scrubbers are relatively efficient devices, but have certain drawbacks. First, the dust entrapped in the water is not recoverable. Second, the waste water containing the dust is required to be properly handled to prevent another source of pollution, since more than approximately 300 gallons per minute may be used. Most wet scrubbers are used in combination with a cyclone collector. The cyclone collects coarser materials and the wet scrubber removes the finer particles.

Baghouses (Fabric Filters)

A baghouse (Figure 3-9) is a large metal housing containing hundreds of synthetic, heat-resistant fabric bags for collecting fines. The fabric bage are usually silicone-treated to increase their ability to collect very fine particles of dust. A baghouse functions much the same way as a vacuum cleaner. A large vacuum fan creates a suction within the housing, which draws in dirty air and filters the air though the fabric of the bags. To handle the huge volume of exhaust gases from the aggregate dryer, a very large number of bags (a typical unit may contain as many as 800) are required.

A baghouse is divided into a dirty gas chamber and a clean gas chamber. The filter bags are contained in the dirty gas chamber, into which the air from the dryer enters. The flow of air carrying the dust particles passes through the fabric of the filter bags, depositing the dust on the surface of the bag. The air then continues to the clean gas chamber. During the operation, the fabric filter traps large quantities of dust. Eventually, the dust accumulates into a "dust cake", that is required to be removed before the dust reduces or stops the flow of gas through the filter. There are many ways of cleaning the bags in a collector, but the most common methods are to flex the bags, back-flush the bags with clean air, or both flex and back-flush. Dust removed from the bags drops into an auger at the bottom of the baghouse and is transferred to a storage silo. The dust may then be returned to the plant or wasted.

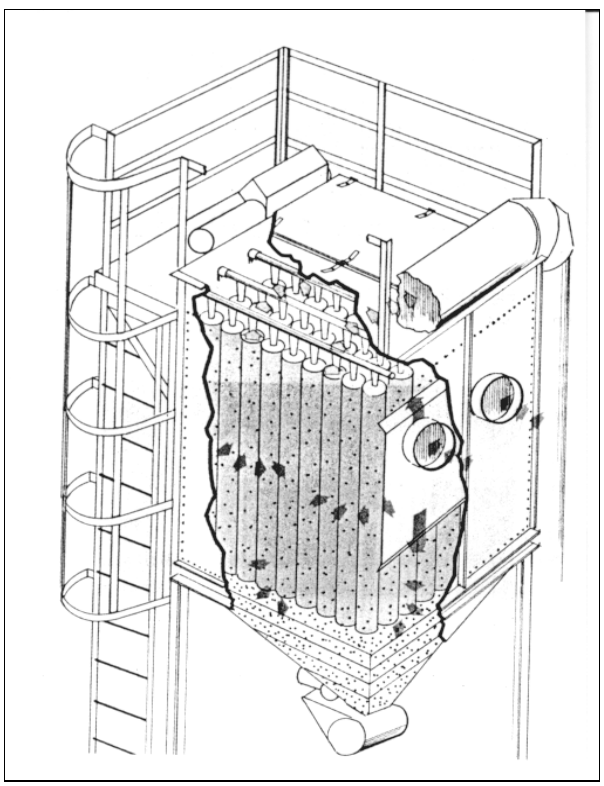

Figure 3-9. Typical Baghouse

HOT MIX ASPHALT STORAGE

To prevent plant shutdowns due to temporary interruptions of paving operations or shortages of trucks to haul HMA from the plant to the paving site, most plants are equipped with surge bins (storage silos) for temporary storage of HMA. When a surge bin is used, the HMA is deposited by conveyor or hot elevator into the top of the bin (Figure 3-10) and is discharged into trucks from the bottom.

Surge bins work well if certain precautions are followed, but may cause segregation of the HMA if not used properly. A good practice is to use a baffle plate or similar device at the discharge end of the conveyor used to load the bin. The baffle helps to prevent the segregation of the HMA as the mixture drops into the bins. A good recommendation is to keep the hopper at least one-third full to avoid segregation as the hopper empties and to help keep the mix hot.

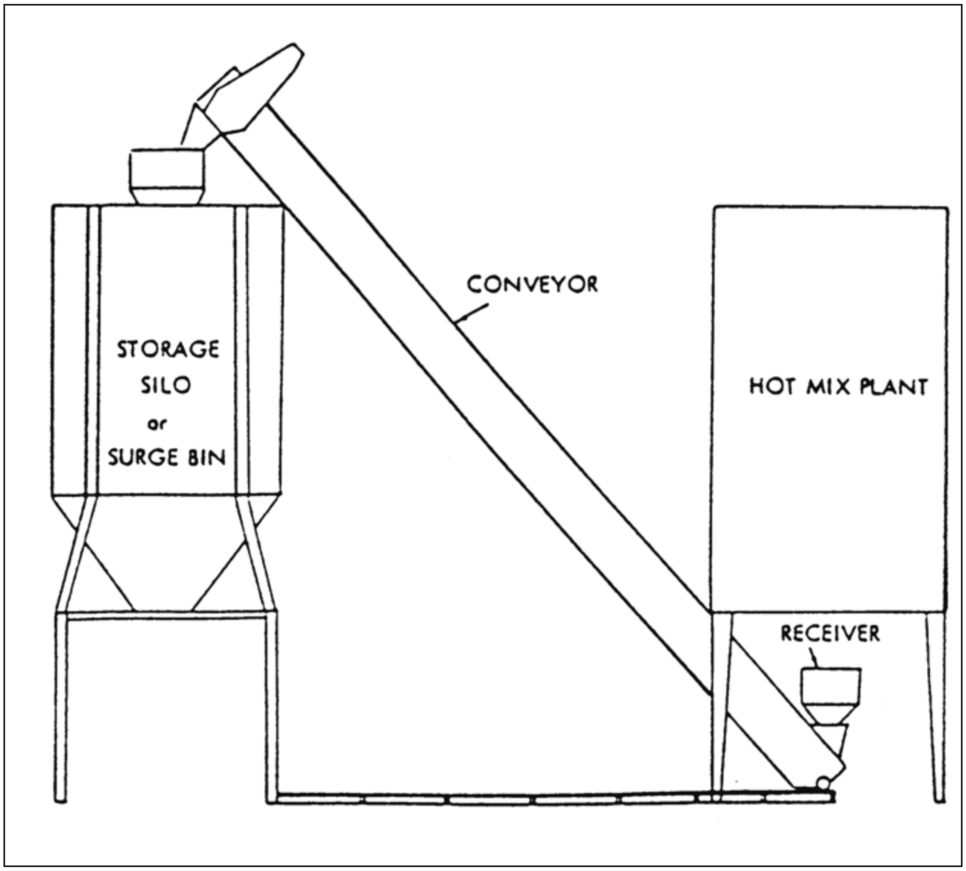

Figure 3-10. Typical Storage Structure Configuration

BATCH PLANTS

Batch plants obtain their name because during operation the HMA is produced in batches. The size of batch varies according to the capacity of the plant pugmill (the mixing chamber where aggregate and binder are blended together). A typical batch is approximately 6000 lb.

BATCH PLANT OPERATIONS AND COMPONENTS

At a batch plant, aggregates are blended, heated and dried, proportioned, and mixed with binder to produce HMA. A plant may be small or large, depending on the type and quantity of HMA being produced, and also may be stationary or portable.

Certain basic operations are common to all batch plants:

1) Aggregate storage and cold feeding

2) Aggregate drying and heating

3) Screening and storage of hot aggregates

4) Storage and heating of binder

5) Measuring and mixing of binder and aggregate

6) Loading of finished HMA

Figure 3-11. illustrates the sequence of these operations.

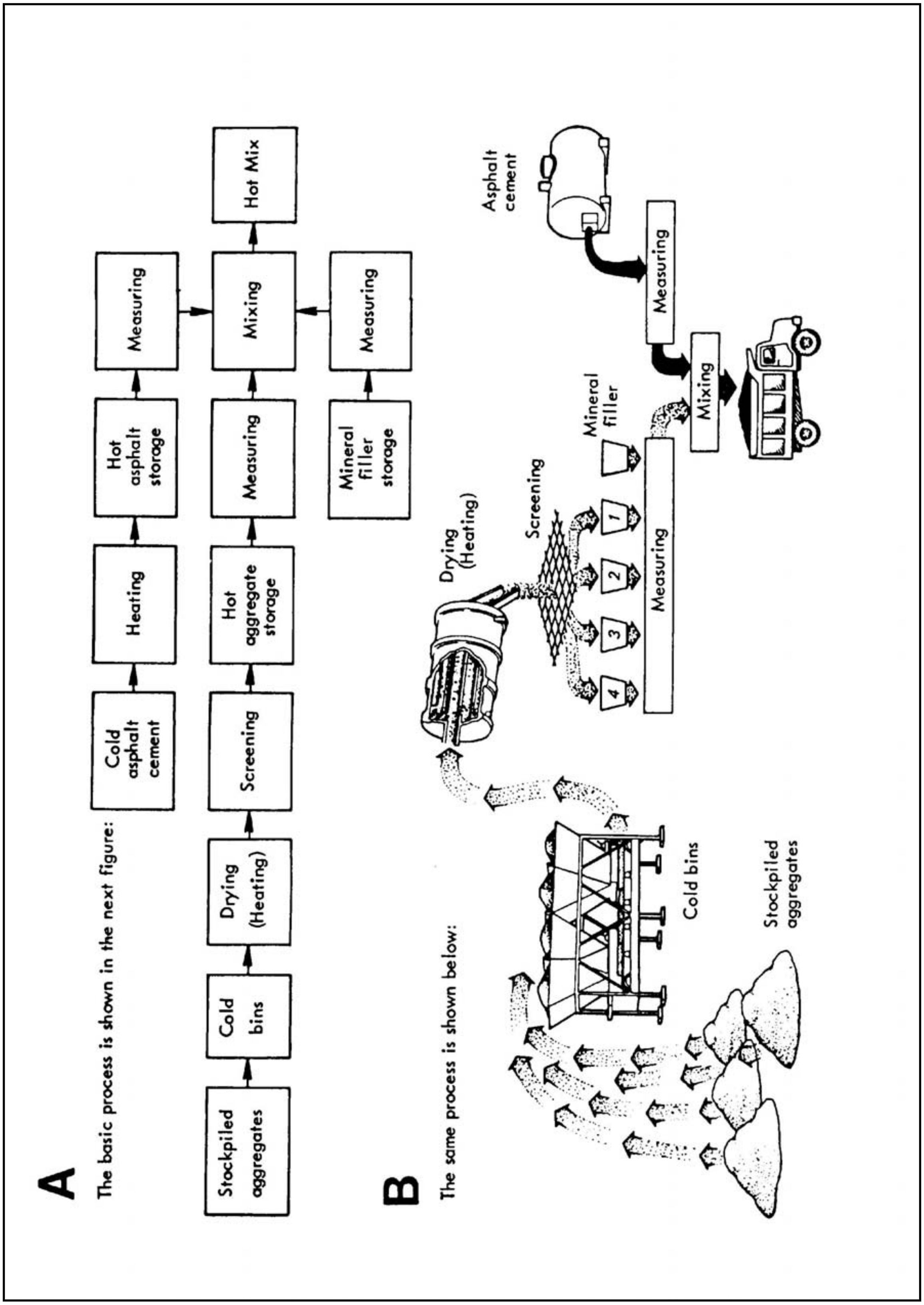

Figure 3-11. Basic Batch Plant Operations Shown (A) in flow chart form and (B) schematically

Aggregates are removed from storage or stockpiles in controlled amounts and passed through a dryer to be dried and heated. The aggregates then pass over a screening unit that separates the material into different sized fractions and deposits the aggregates for hot storage. The aggregates and mineral filler (when used) are then withdrawn in controlled amounts, combined with binder, and thoroughly mixed in a batch. The HMA is loaded directly into trucks or placed in a surge bin, and hauled to the paving site.

Figure 3-12 illustrates the major components of a typical batch plant. Each component or group of related components is discussed in detail in sections that follow; however, an overview of the processes required in plant operations helps the Technician to understand the functions and relationships of the various plant components.

Cold (unheated) aggregates stored in the cold bins (1) are proportioned by cold-feed gates (2) on to a belt conveyor or bucket elevator (3), which delivers the aggregates to the dryer (4), the aggregate is dried and heated. Dust collectors (5) remove undesirable amounts of dust from the dryer exhaust. Remaining exhaust gases are eliminated through the plant exhaust stack (6). The dried and heated aggregates are delivered by hot elevator (7) to the screening unit (8), which separates the material into different sized fractions and deposits the aggregates into separate hot bins (9) for temporary storage. When needed, the heated aggregates are measured in controlled amounts in to the weigh box (10). The aggregates are then dumped into the mixing chamber or pugmill (11), along with the proper amount of mineral filler, if needed, from the mineral filler storage (12). Heated binder from the hot binder storage tank (13) is pumped into the binder weigh bucket (14) which weighs the binder prior to delivery into the mixing chamber or pugmill where the binder is combined thoroughly with the aggregates. From the mixing chamber, the HMA is deposited into a waiting truck or delivered by conveyor into a surge bin.

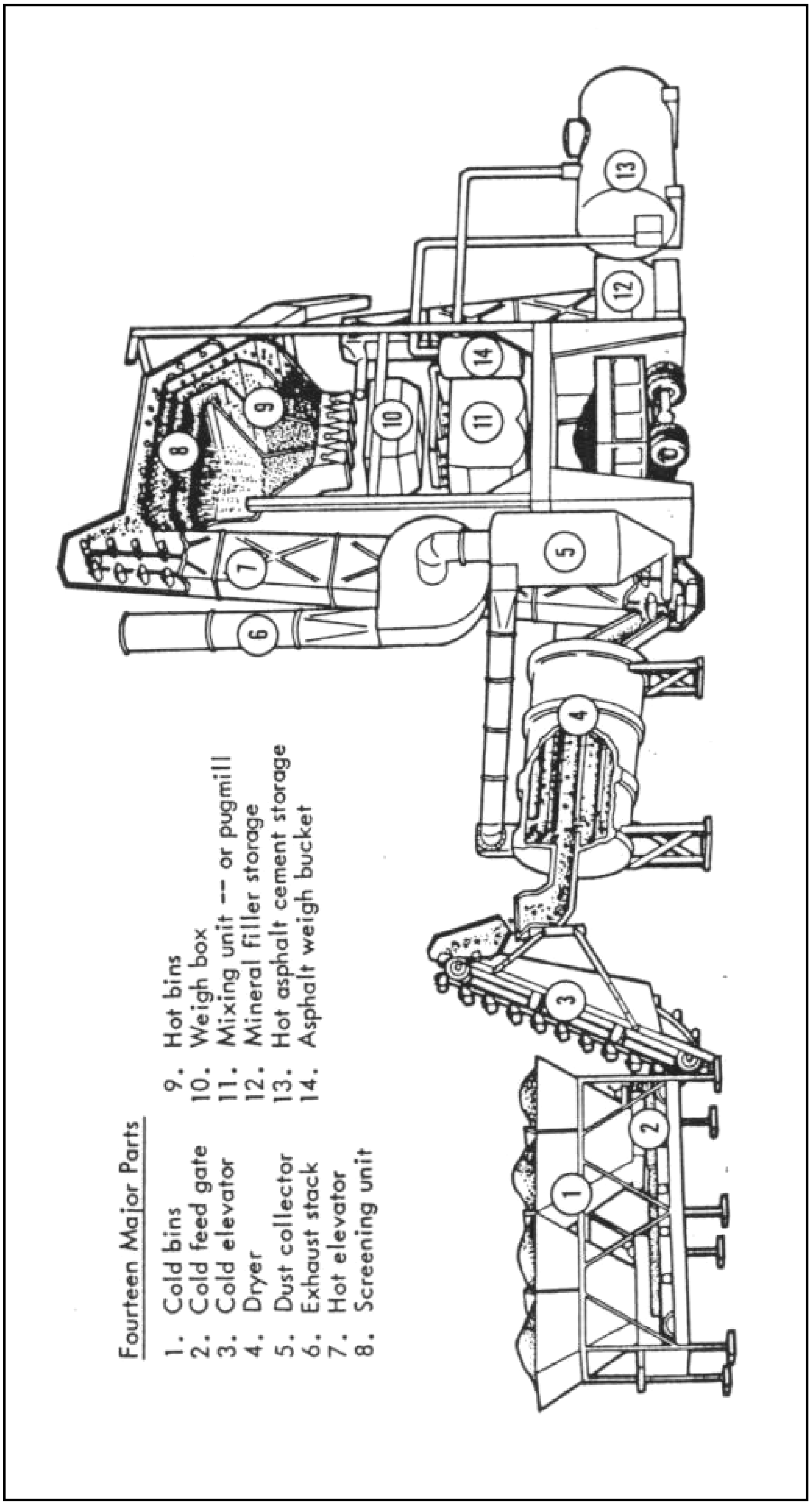

Figure 3-12. Major Batch Plant Components (Many plants also include a baghouse in addition to the dust collector shown in number 5 above.)

AGGREGATE COLD FEED

The handling, storage, and cold feed of aggregates in a batch plant is similar to that in other types of plants. Particular to batch plants are: (1) uniform cold feed, (2) proportioning of cold aggregates, (3) types of feeders and controls, and (4) cold-feed inspection.

Uniform Cold Feed

Fine and coarse aggregates of different sizes are placed into separate cold bins (Figure 3-13). The bins are required to be kept sufficiently full at all times to ensure there is enough material for a uniform flow through the feeder. Uniform cold feeding is necessary for several reasons. Among them are:

1) Erratic feeding from the cold bins may cause some of the hot bins to overfill while others may be low on materials

2) Wide variations in the quantity of a specific aggregate at the cold feed (particularly in the fine aggregate) may cause considerable change in temperature of the aggregates leaving the dryer

3) Excessive cold feed may overload the dryer or the screens

4) Wide variations may affect moisture content in the HMA

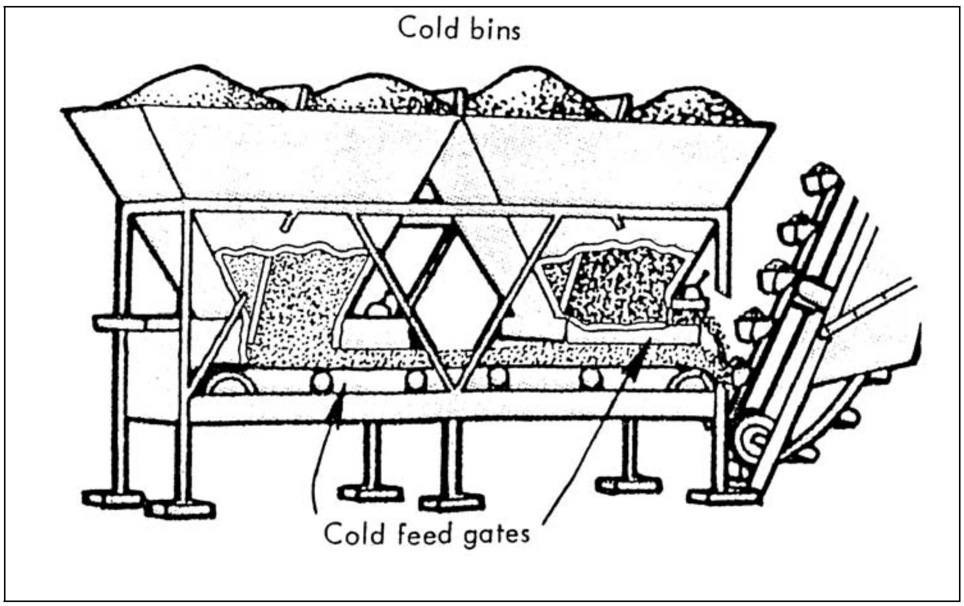

Figure 3-13. Cold Feed System

All of these problems contribute to non-uniform HMA at the plant that in turn causes problems with the pavement. Therefore, controlling the cold feed is the key to all subsequent operations.

Proportioning of Cold Aggregates

Accurate proportioning of cold aggregates is important because, except for the small amount of degradation that may occur during drying and screening, the aggregate gradation in the hot bins is dependent on the cold feed. To ensure that the hot bins remain in balance, (i.e., contain the correct proportions of different sized aggregate to produce the desired HMA gradation), the proportions of aggregates leaving the cold bins are required to be carefully monitored and controlled.

If the sieve analysis of the cold-feed material indicated any significant difference from the requirements of the job mix formula, the quantities being fed by the various cold-feed bins are required to be adjusted to correct the gradation. This does not require recalibrating the bins. Simply adjusting the flow rate based on data from the calibration charts corrects the problem.

Type of Feeders and Controls

Aggregate feed units are located beneath the storage bins or stockpiles, or in positions that assure a uniform flow of aggregate. Feeder units have controls that may be set to produce a uniform flow of aggregate to the cold elevator (Figure 3-14).

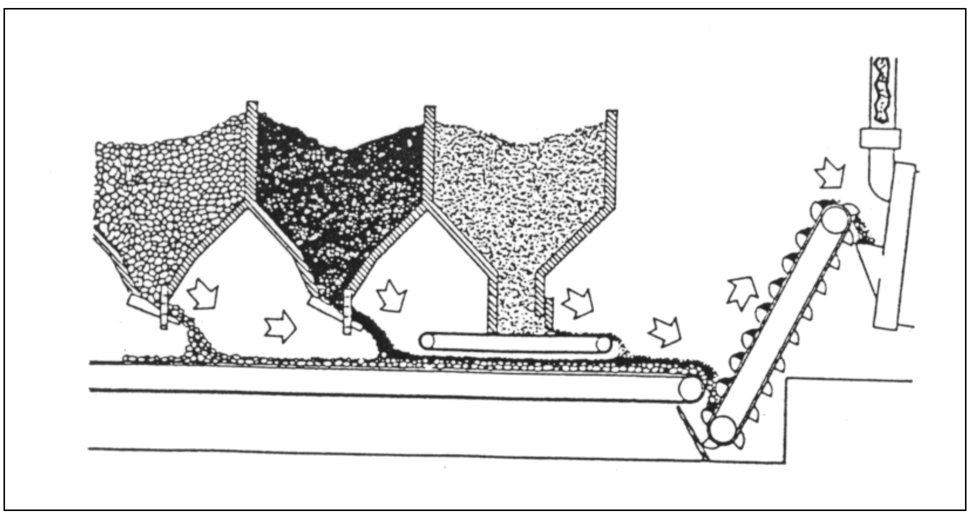

Figure 3-14. Three Bin Cold Feeder and Belt

Generally belt and vibratory feeders are best for accurate metering of the fine aggregates. Coarse aggregates usually flow satisfactorily with any type of feeder.

For a uniform output from the batch plant, input is required to be accurately measured. Feeding the exact amounts of each sized aggregate into the dryer at the correct rate of flow is important.

Inspection of Cold Feed

The Technician is required to observe the gate calibration procedures. During production, the gate-opening indicators are required to be periodically checked to ensure that gate openings remain properly set.

The Technician is required to frequently observe the cold feed to detect any variations in the amount of aggregates being fed. Sluggish feeders may be caused by material bridging over the gates instead of flowing through. Sluggish feeders also may be the result of excessive aggregate moisture or other factors that impede a uniform flow of material to the dryer.

AGGREGATE DRYING AND HEATING

From the cold bins, aggregates are delivered to the dryer. The dryer removes moisture from the aggregates and raises the aggregate temperature to the desired level. Basic dryer operation, temperature control, calibration of temperature indicators, and moisture checks are important.

Dryer Operation

The conventional batch plant dryer is a revolving cylinder ranging from 5 to 10 ft in diameter and 20 to 40 ft in length. The dryer has an oil or gas burner with a blower fan to provide the primary air for combustion of the fuel, and an exhaust fan to create a draft through the dryer (Figure 3-15). The drum also is equipped with longitudinal troughs or channels, called flights that lift and drop the aggregate in veils through the burner flame and hot gases (Figure 3-16). The slope of the dryer, rotation speed, diameter, length and arrangement, and number of flights determine the length of time the aggregate spends in the dryer.

For efficient dryer operation, the air that is combined with the fuel for combustion is required to be in balance with the amount of fuel oil being fed into the burner. The exhaust fan creates the draft of air that carries the heat through the dryer and removes the moisture. Imbalance among these three elements causes problems. The lack of sufficient air or excess flow of fuel oil may lead to incomplete combustion of the fuel. The unburned fuel leaves an oily coating on the aggregate particles, which may adversely affect the finished HMA.

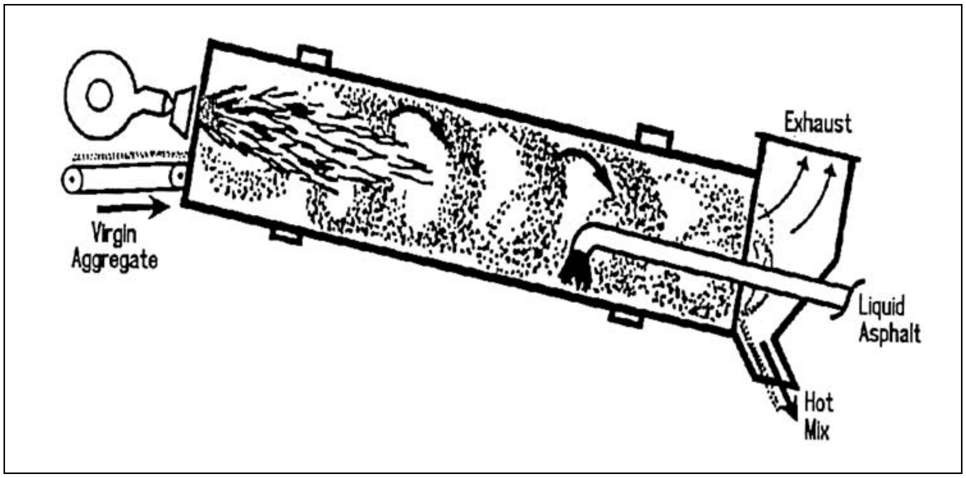

Figure 3-15. Typical Dryer

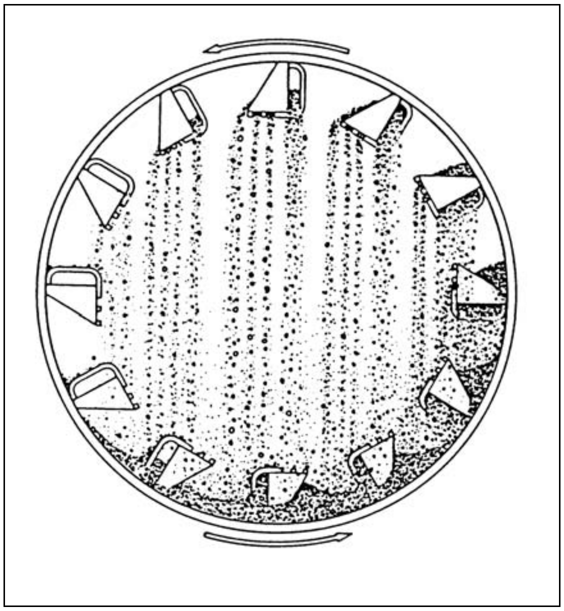

Figure 3-16. Dryer Flights

A quick procedure to check if oil is coating the aggregate is to place a shovel full of aggregate being discharged from the dryer in a bucket of water. A film of oil floats to the surface if there is oil on the aggregate. A slight film is not of concern; however, a heavy film on the surface of the water requires immediate attention.

Imbalance between draft air and blower air velocities may cause a back pressure within the drum. This creates a "puff back" of exhaust at the burner end of the drum, indicating that draft air velocity is insufficient to accommodate the air pressure created by the burner blower. In such a case, either the resistance to draft air is required to be reduced or blower air pressure decreased.

Generally, dryers are designed to be most efficient when heating and drying aggregates have a given (typically 5 percent) moisture content. If the aggregate moisture content is higher than that for which the dryer is designed, the aggregates being fed to the dryer are required to be reduced in quantity. Consequent to this reduction, there is a drop in the dryer hourly capacity.

Dryers with natural gas or liquid petroleum burners rarely develop combustion problems; however, imbalances among gas pressure, combustion air and draft may still occur.

The fuel consumption in the drying of the aggregates is the most expensive operation in HMA production and is also one of the most common bottlenecks in plant operation. The production rate of the entire plant is dependent upon the dryer's efficiency. HMA may not be produced any faster than the aggregates are dried and heated.

Temperature Control

Proper aggregate temperature is essential. The temperature of the aggregate, not the binder, controls the temperature of the HMA. The layer of binder put on each particle of aggregate during mixing assumes the temperature of that aggregate almost instantaneously. Aggregates that are heated to an excessive temperature may harden the binder during mixing. Underheated aggregates are difficult to coat thoroughly with binder and the resulting mix is difficult to place on the roadway.

A temperature-measuring device called a pyrometer is used to monitor aggregate temperature as the material leaves the dryer. (Figure 3-17) There are two types: (A) indicating pyrometers and (B) recording pyrometers (Figure 3-18). The recording head of a pyrometer is usually located in the plant control room.

A good temperature-indicating device assists the plant Technician by providing:

1) Accurate temperature records

2) Indications of temperature fluctuations that may be caused by lack of control and uniformity in drying and heating operations

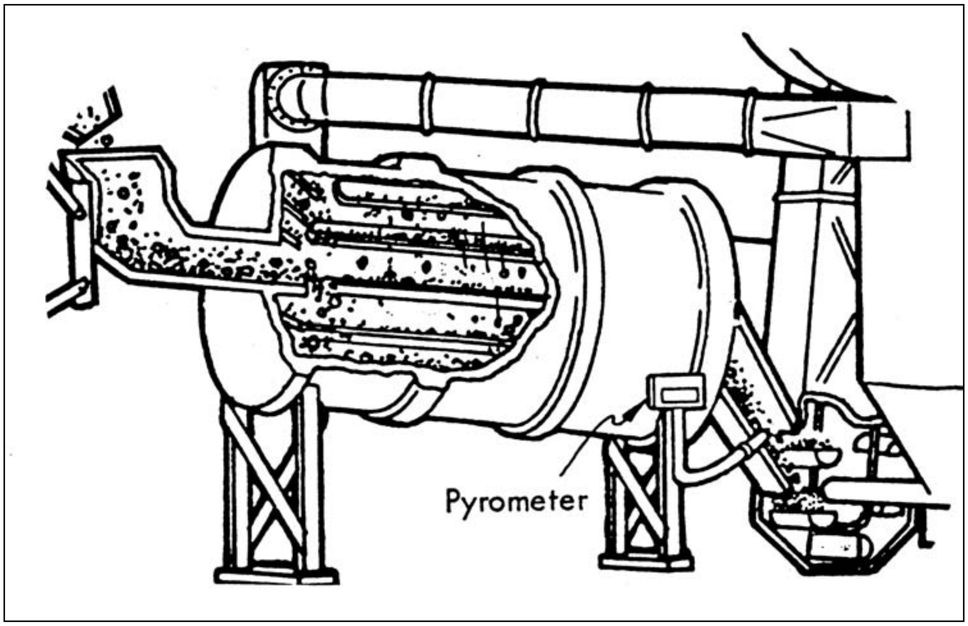

Figure 3-17. Pyrometer Located at Discharge Chute of Dryer

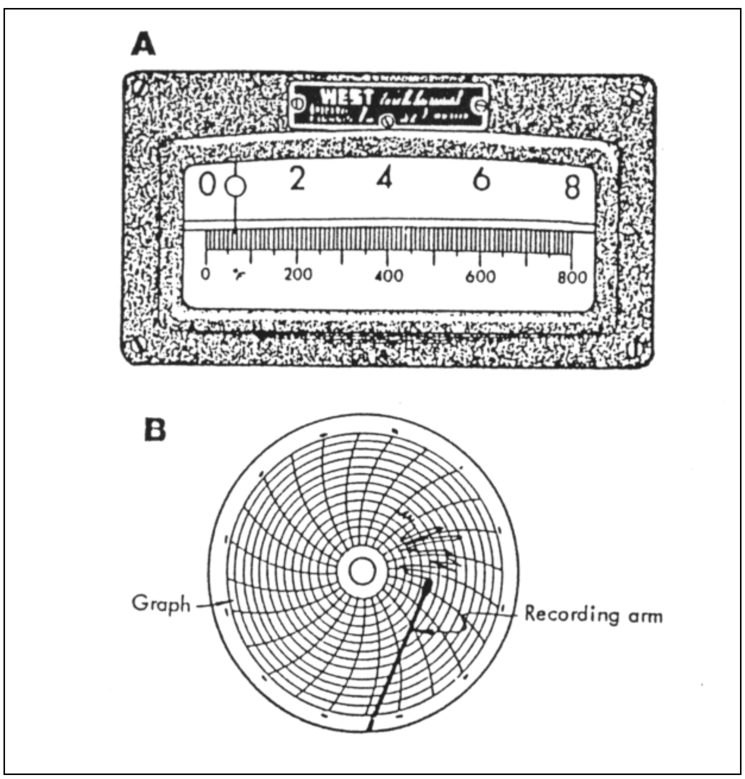

Figure 3-18. Typical Types of Pyrometers:
(A) Indicating Pyrometer (B) Recording Pyrometer

Calibration

Both types of electrical temperature-indicating devices (pyrometers) are quite similar in operation. In each, the sensing element, which is a shielded thermocouple, protrudes into the main hot aggregate stream in the discharge chute of the dryer.

Pyrometers are sensitive instruments that measure the very small electrical current induced by the heat of the aggregate passing over the sensing element. The head (indicating element) of the device is required to be completely shielded from the heat and plant vibrations, located at least a meter away from the dryer, and connected to its sensing element by wires. Any change in the connecting wire length, size splices, or couplings requires a recalibration of the device.

The major difference between recording pyrometers and indicating pyrometers is that indicating pyrometers give a dial or digital reading while recording pyrometers record aggregate temperatures on paper in graph form, thus providing a permanent record.

The best way to check the accuracy of a pyrometer is to insert the sensing element of the device and an accurately calibrated thermometer into a hot oil or asphalt bath. Being cautious of the flash point of the oil or asphalt, the batch is slowly heated above the temperature expected of the dried aggregate and the readings of the two instruments are compared.

Another means to check a temperature-indicating device is to take several shovelfuls of hot aggregate from the dryer discharge chute and dump them in a pile on the ground. Then take another shovelful and place the material, shovel and all, on top of the pile. The pile keeps the shovelful of aggregate hot while the temperature is taken. Inserting the entire stem of an armored thermometer into the aggregate in the shovel gives a temperature reading that may be compared to the reading on the pyrometer. Several thermometer readings may be necessary to get accurate temperature data.

Moisture Check

Checks for moisture in the hot aggregate may be made at the same time as temperature indicator checks. Quick moisture checks are useful in determining if more precise laboratory moisture tests are required to be conducted.

To make a quick moisture check, a pile of hot aggregate from the dryer discharge is required to be built up and a shovelful of aggregate placed on top of the pile. Then, the Technician inspects the shovelful of aggregate as follows:

1) Observe the aggregate for escaping steam or damp spots. These are signs of incomplete drying or porous aggregate releasing internal moisture that may or may not be detrimental. This type of visual check becomes more accurate as the Technician becomes more familiar with the aggregate being used.

2) Take a dry, clean mirror, shiny spatula, or other reflective item which is at normal ambient temperature or colder, and pass the item over the aggregate slowly and at a steady height. Observe the amount of moisture that condenses on the reflective surface. With practice, the Technician is able to detect excessive moisture fairly consistently.

SCREENING AND STORAGE OF HOT AGGREGATE

After the aggregates have been heated and dried, they are carried by a hot elevator (an enclosed bucket conveyor) to the gradation unit. In the gradation unit, the hot aggregate passes over a series of screens that separate the aggregate into various-sized fractions and deposit those fractions in "hot" bins (Figure 3-19).

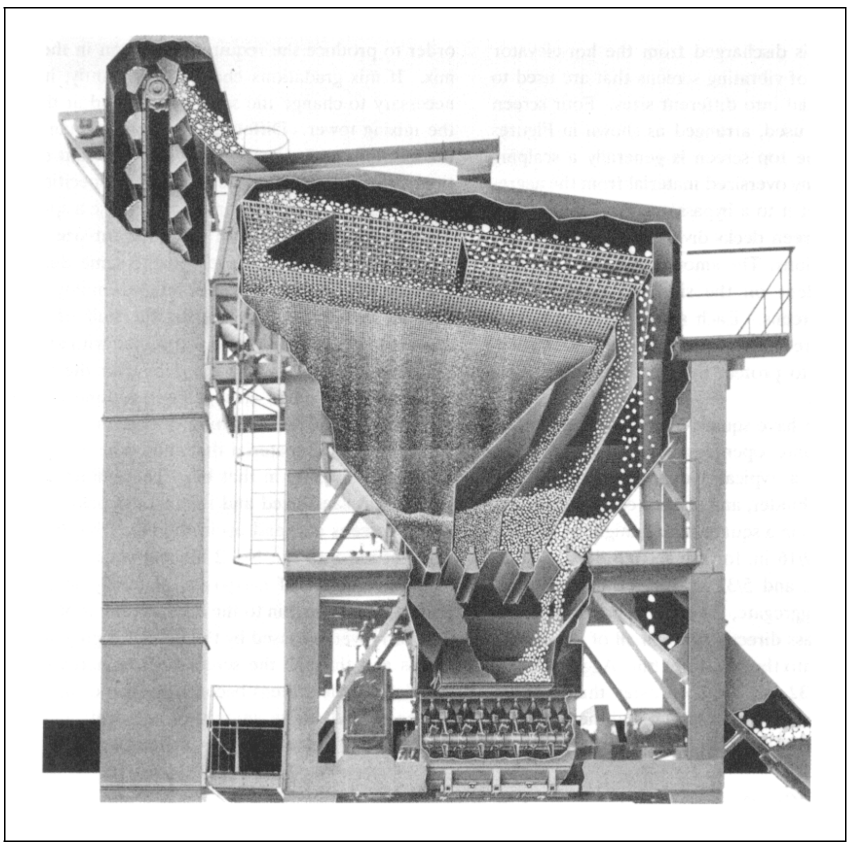

Figure 3-19. Cutaway View Showing Details of Flow Material Through Screens and Bins

Hot Screens

The screening unit includes a set of several different-sized vibrating screens (Figure 3-20). The first in the series of screens is a scalping screen that rejects and carries off oversized aggregates. This is followed by one or two intermediate-sized screens, decreasing in size from top to bottom. At the bottom of the stack is a sand screen.

The screens serve to separate the aggregate into specific sizes. To do this function properly, the total screen area is required to be large enough to handle the total amount of feed delivered. The screens are required to be cleaned and in good condition. The capacity of the screens is required to be in balance with the capacity of the dryer and the capacity of the pugmill. When too much material is fed to the screens or the screen openings are plugged, many particles which should pass through, ride over the screens, and drop into a bin designed for a larger size of particles. Similarly, when screens are worn or torn, resulting in enlarged openings and holes, oversized material goes into bins intended for smaller-sized aggregate. Any misdirection of a finer aggregate into a bin intended to contain the next larger size fraction is called "carry-over".

Excessive carry-over may add to the amount of the fine aggregate in the total mix, thus increasing the surface area to be covered with binder. If the amount of carry-over is unknown or fluctuates, particularly in the No. 2 bin, the carry-over may seriously affect the mix design in both gradation and binder content. Excessive carry-over may be detected by a sieve analysis of the contents of the individual hot bins and is required to be corrected immediately by cleaning the screens or reducing the quantity of material coming from the cold feed, or both. Some carry-over is allowed in normal screening and the permissible amount of carry-over in each bin is specified.

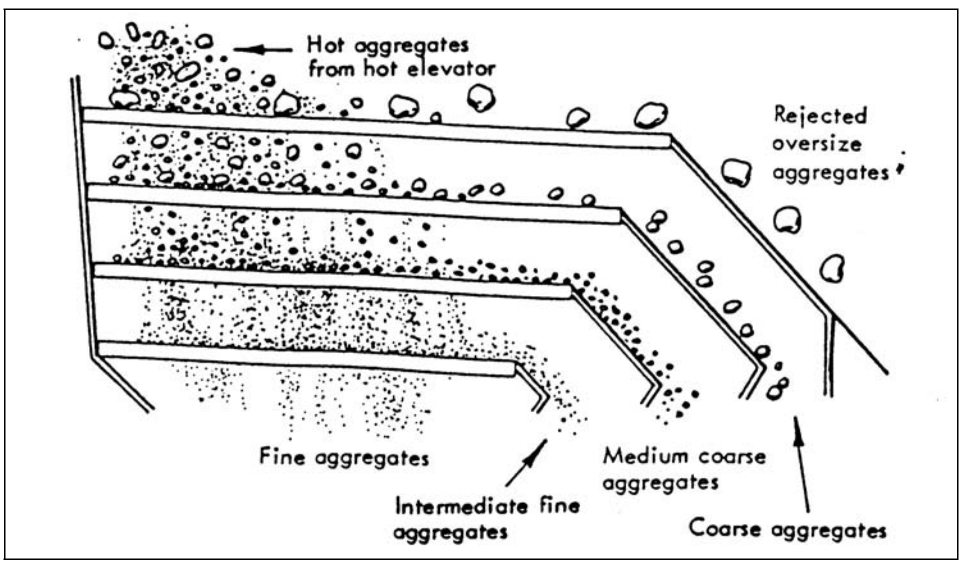

Figure 3-20. Screening Unit

The No. 2 bin (intermediate fine aggregate) is the critical bin for carry-over. This is the bin that receives the finest aggregate in carry-over that affects the binder demand of the HMA the most. Typically, the carry-over in the No. 2 bin may not exceed 10 %. Running a sample of the No. 2 bin material over a No. 4 sieve indicates the amount of carry-over.

To prevent excessive carry-over, daily visual inspection of the screens for cleanliness and overall condition is recommended, preferably before starting each day's operation.

Hot Bins

Hot bins are used to temporarily store the heated and screened aggregates in the various sizes required. Each bin is an individual compartment or segment of a large compartment divided by partitions. A properly sized hot-bin installation is required to be large enough to hold sufficient material of each size when the mixer is operating at full capacity. The partitions are required to be tight, free from holes, and high enough to prevent intermingling of the aggregates.

Hot bins usually have indicators that tell when the aggregates fall below a certain level. These indicators may be either electronic or mechanical. One such electronic indicator (diaphragm type) is mounted on the side of the bin (Figure 3-21). The pressure of the aggregate in the bin makes the indicator work. When the aggregate level drops below the indicator, an electrical contact turns on a warning light.

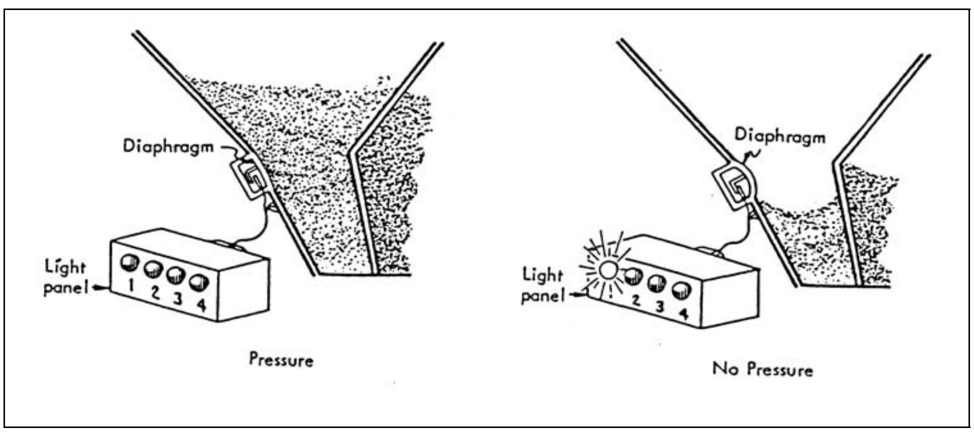

Figure 3-21. Diagram of a Diaphragm Type Cut-Off

Each bin is required to be equipped with an overflow pipe to prevent excess amounts of aggregate from backing up into the other bins. The overflow pipes are required to be set to stop overfilling the bins. When a bin overfills, the screen above the bin rides on the aggregate, resulting in a heavy carry-over and possible damage to the screens. Overflow pipes are required to be checked frequently to make sure that the pipes are free flowing.

Sometimes the very fine aggregate hangs up in the corners of the fine aggregate bin. When this build-up collapses, an excessive amount of fines may be added to the HMA. This rush of fine materials usually occurs when the aggregate level in the bin is drawn down too low. The solution is to maintain a proper aggregate level in the bin. Also, fillet plates welded into the corners of the bin minimizes the build-up of the fines.

Other potential obstacles to a good HMA include shortage of material in one bin (and excess in another), worn gates in the bottom of a bin (allowing leakage of aggregate into the weigh hopper), and sweating of the bin walls (caused by condensation of moisture).

Hot bins may not be allowed to run empty. Bin shortages or excesses are corrected by adjusting the cold feed. For example, if the coarse bin is overflowing while the others remain at satisfactory level, the cold-bin feed supplying most of the coarse aggregate is required to be reduced slightly.

Making two feed adjustments at once is not a good practice. For example, if the total feed is deficient and also one bin is running a little heavy, adjust the total feed is adjusted first and then an adjustment to the feed is made on the one bin that is running heavy.

Gates at the bottom of a bin that are worn and leaking material are required to be repaired or replaced immediately. Leakage from a hot bin may adversely affect gradation of the final HMA.

Sweating occurs when moisture vapor in the aggregate and in the air condense on the bin walls. This usually occurs at the beginning of the day's operation or when the coarse aggregate is not thoroughly dry. Sweating may cause the accumulation of dust, resulting in excessive surges of fines in the HMA. Mineral filler and dust from the baghouse are required to be stored separately in moisture-proof silos and fed directly into the weigh hopper.

Hot Bin Sampling

Batch plants are equipped with devices for sampling hot aggregate from the bins. These devices divert the flow of aggregate from the feeders or gates under the bins into sample containers.

From the flow of material over the plant screens, fine particles fall to one side of each bin and coarse particles to the other (Figure 3-22). When material is drawn from the bin by opening a gate at the bottom, the stream consists predominantly of fine material at one edge and coarse material at the other. Therefore, the position of the sampling device in the stream of material discharged from a bin determines whether the sample is composed of a fine portion, a coarse portion, or an accurate representation of the material in the bin (Figure 3-23). This condition is especially critical in the No. 1 (fine) bin, since the material in this bin strongly influences the amount of binder required in the HMA.

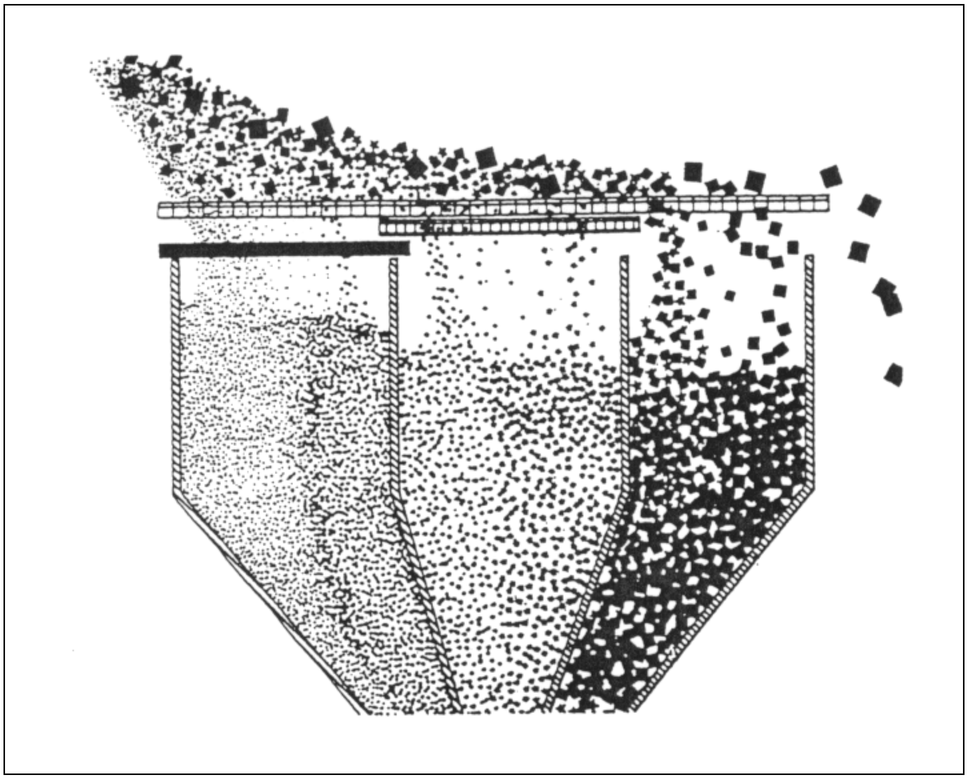

Figure 3-22. Segregation of Aggregates in Hot Bins

Stratification (vertical laying) of sizes in the bin may occur by variations of grading in the stockpiles or by erratic feeding of the cold aggregate. When this form of segregation exists, representative samples are not obtained even when the sampling device is used correctly.

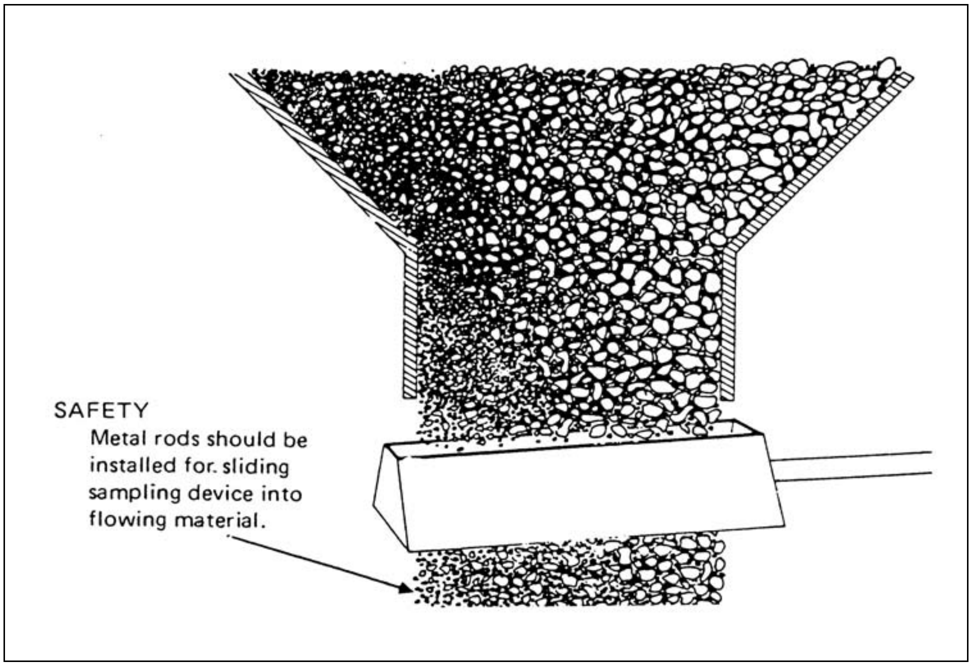

Figure 3-23. Correct Use of Sampling Device

INTRODUCING THE BINDER

From the weigh hopper, the aggregates are deposited into the plant pugmill (mixing chamber) to be blended with the proper proportion of binder. In the typical plant system, binder is weighed separately in a weigh bucket before being introduced into the pugmill. When the weight of binder in the bucket reaches a predetermined level, a valve in the delivery line closes to prevent excess binder from being discharged into the bucket. The binder is then pumped through spray bars into the pugmill (Figure 3-24). Binder buckets are required to be checked for accuracy the first thing each morning. When the plant is started each day, new binder loosens some of the old binder that accumulated the previous day on the sides and bottom of the bucket. Loss of this accumulated binder changes the tare weight of the bucket.

A malfunction of the binder distribution system results in non-uniform distribution of the binder in the HMA. Visual inspection and tests of the finished HMA usually will reveal any functional problems with the system. Generally there are few problems with the binder distribution system.

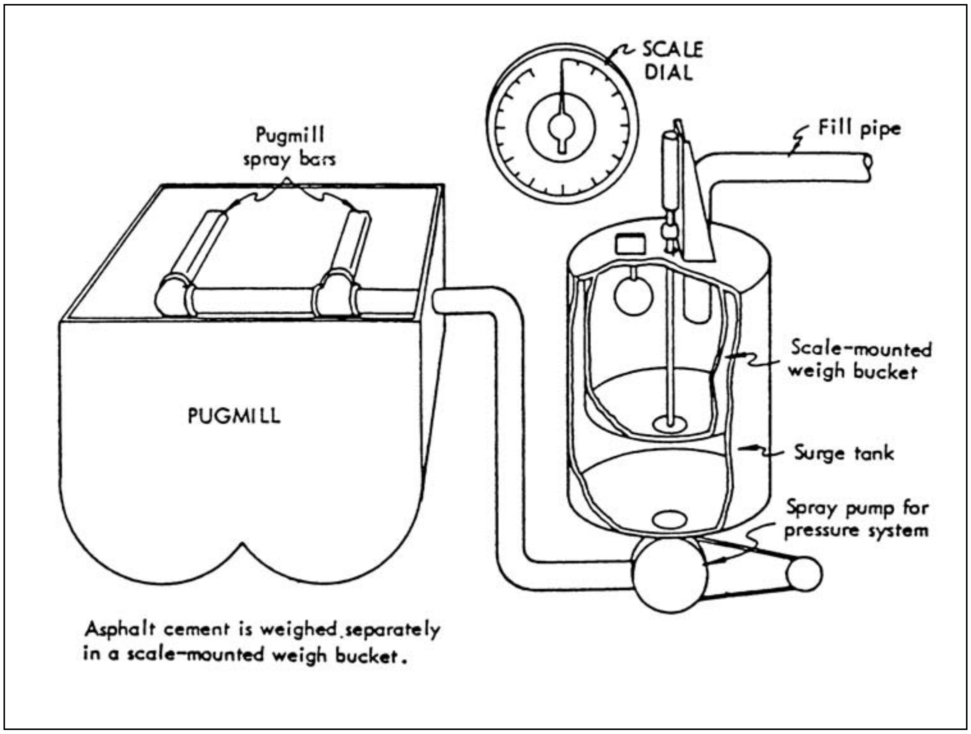

Figure 3-24. Binder Measuring & Delivery System

PUGMILL MIXING

The chamber in which the binder and aggregates are mixed is called a pugmill. The pugmill consists of a lined mixing chamber with two horizontal shafts on which several paddle shanks, each with two paddle tips, are mounted. The paddle tips are adjustable and easily replaced.

In general, the paddles are required to be set so that there are no "dead areas" in the pugmill. A dead area is a place where material may accumulate out of reach of the paddles and not be thoroughly mixed. Dead areas may be avoided by being certain that clearance between the paddle tips and the liner is less than one-half the maximum aggregate size. Paddles that have worn considerably or are broken are required to be readjusted or replaced prior to plant startup.

Non-uniform mixing may occur if the mixer is over-filled (Figure 1-25). At maximum operating efficiency, the paddle tips are required to be barely visible at the surface of the material during mixing. If the material level is too high, the uppermost material tends to "float" above the paddles and is not thoroughly mixed. Conversely, in a pugmill containing too little material (Figure 3-26), the tips of the paddles rake through the material without actually mixing the HMA.

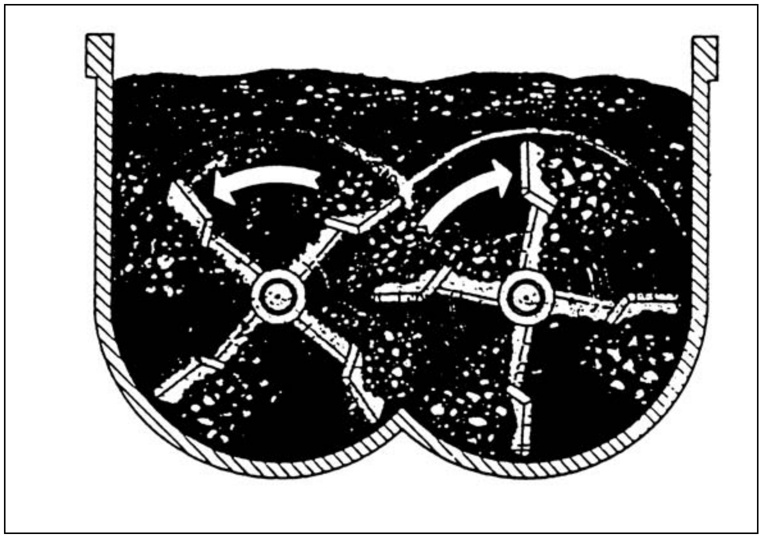

Figure 3-25 - Overfilled Pugmill

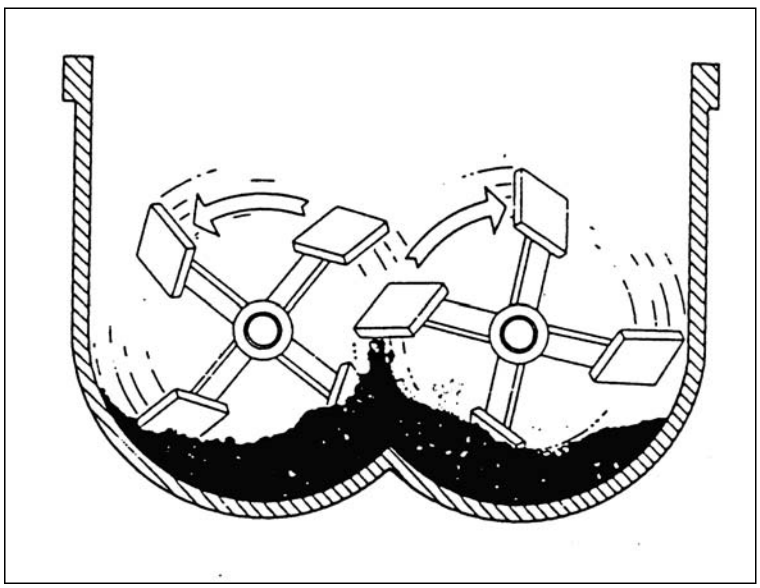

Figure 3-26. Underfilled Pugmill

Either of these two problems may be avoided by maintaining the amount of HMA in the pugmill near the batch capacity. Normally the manufacturer recommends that the batch capacity be a percentage of the capacity of the pugmill "live zone". This live zone (Figure 3-27) is the net volume in cubic feet below a line extending across the center of the mixer shafts with shafts, liners, and paddles and tip deducted.

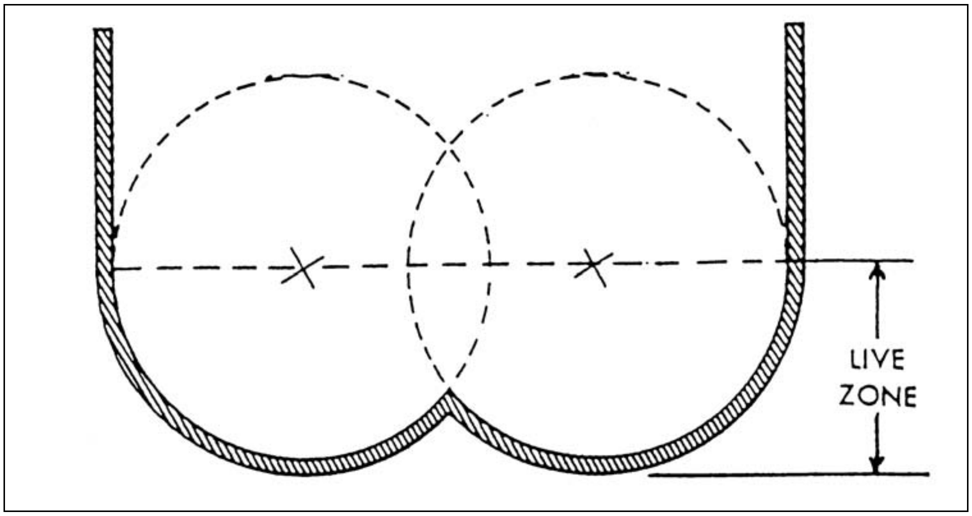

Figure 3-27. Pugmill "Live Zone"

Figure 3-28 illustrates the mixing cycle during which binder, aggregates, and mineral filler are blended in HMA in the pugmill. The length of time between the opening of the weigh box (hopper) gate (Step 1 in the figure) and the opening of the pugmill discharge gate (Step 4) is referred to as the batch mixing time. The batch mixing timeis required to be long enough to produce a homogenous mix of evenly distributed and uniformly coated aggregate particles. However, if the mixing time is too long, the lengthy exposure of the thin binder film to the high aggregate temperature in the presence of air may adversely affect the binder and reduce the durability of the mix. To monitor batch mixing time, some type of timing device is used.

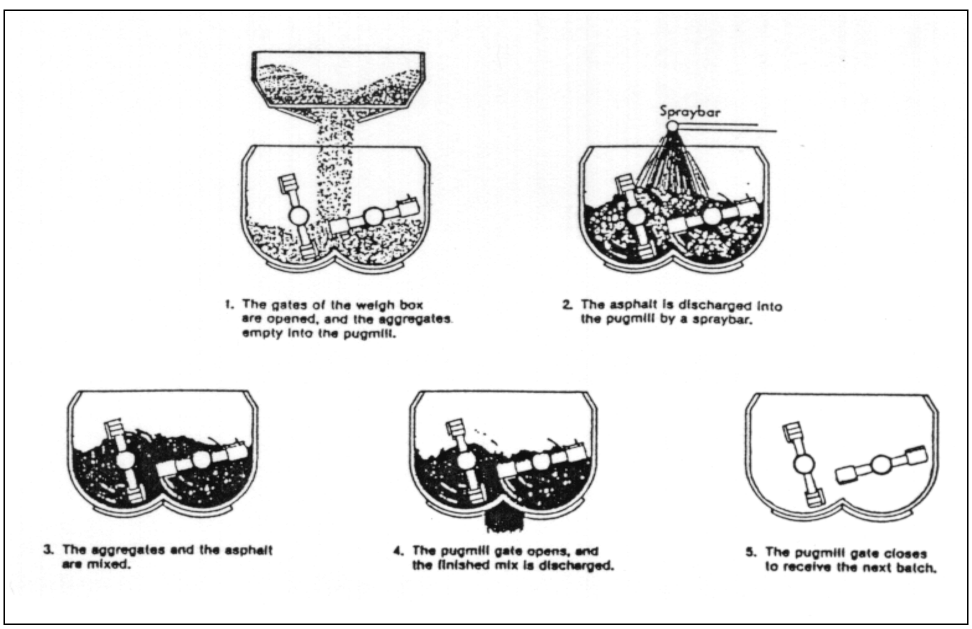

Figure 3-28. Steps in a Typical Batch Plant Cycle

BATCH PLANT OPERATION

Batch plants are classified into three categories, depending upon their degree of automation: manual, semi-automatic, and automatic. In manual plant operation, each phase of the batching is conducted by manipulation of a lever, a switch, or a button. Even in the manual plants, however, pneumatic or hydraulic cylinders actuated by electric switches have replaced the hand levers of early plants. Also, all plants, regardless of their classification, utilize power operation of the weighing, mixing and discharge devices. Power equipment operates bin gates, fines feeders, binder supply and spray valves, weigh box discharge gate, and the pugmill discharge gate.

The semi-automatic plant is one in which a number of the several phases of batching is done automatically. Most semi-automatic plants are arranged so that the operations of the weigh box discharge gate, the binder weigh bucket, the wet mixing, and the operation of the pugmill discharge gate are operated automatically. Limit switches ensure that all functions occur in the proper sequence.

The fully automatic plant is almost completely self-acting. Once mix proportions and timers are set and plant operation is begun, the plant machinery repeats the weighing and mixing cycle until the operator stops the operation or until a shortage of material or some other extraordinary event causes the plant controls to halt operation.

The principal controls on an automatic batch plant include:

1) Automatic cycling control

2) Automatic proportioning control

3) Automatic dryer control

4) A console control panel

5) Formula setting;

6) Tolerance controls

7) Batching interlocks

8) Recording unit

A listing of the various automatic controls is provided in Figure 3-29.

Plant Element	Automatic Control	Function
Cold Aggregate Feed	Bin Gate Operators	Vary gate opening to control amount of material metered
	Feed Belt Drive	Varies speed of belt to control amount of material metered from each compartment
Asphalt System	Tank Heater	Keeps asphalt at proper temperature
	Pump	Controls timing and rate of feed
	Bucket	Weighs out, within tolerances, amount of asphalt called for in batch; delivers asphalt to pugmill
Mineral Filler System	Elevator, Screw	Stops feed when proper weight is delivered
Dryer	Burner	Adjusts heating rate to heat aggregates to proper temperature
Dust Collector	Motor Controller	Activates unit when plant starts up
Hot Bins	Indicator	Shows level of material
Weigh Hopper	Scales	Weighs out, within tolerances, amount of each aggregate material called for in a batch; stops batching if any material is short
	Gate Operator	Dumps completed batch into mixer and closes gate
	Cycling	Repeats batch to produce full load
Pugmill	Mixer	Times wet mix cycle
	Mixer Gate Operator	Dumps finished batch into hauler and closes gate

Figure 3-29. Automatic Controls for Batch Plants

The automatic cycling control draws aggregates and binder according to a pre-set batching formula. The opening and closing of the weigh hopper, discharge gate, binder valve, and the pugmill discharge gate are activated automatically, without any intermediate manual control. The system includes pre-set timing devices to control the desired period of the wet mixing cycle and automatic equipment is available to determine if the quantities drawn are within the specification limits. Settings on these devices are required to be checked for accuracy at least once a week.

The automatic proportioning control and the automatic cycling control work together through pre-set interlock devices. The Technician is required to become familiar with the plant and know how to check the function of the interlock system.

The automatic dryer control automatically regulates the temperature of the aggregates discharged from the dryer within a pre-set range.

The batching console panel contains all the switches and circuits for automatic batching, including the batch weight pre-set controls, interlock controls, tolerance controls, and limit switches. The console is usually located within a separate air-conditioned room (Figure 3-30) to exclude the influence of heat, dust, and vibration, that may cause malfunctions in the system.

Figure 3-30. Control Station for Automated Plant

The recording unit is connected to the scale circuitry and automatically provides a record of the weight of material incorporated into each batch of HMA. The record may be in the form of a graph-strip chart where a continuous line represents material weight, or a continuous tape of printed numbers that represent batching weight.

PLANT INSPECTION GUIDELINES

Regardless of whether a batch plant is manual, semi-automatic, or completely automatic, certain basic plant components and functions are required to be inspected regularly to ensure that the plant is capable of producing HMA that meets specifications. Below is a list of items that the Technician is required to check regularly at all types of batch plants.

Batch Plant Inspection Items

1) Proportioning of cold feed aggregates is accurate to ensure proper blend of materials and the proper balance of material in the hot bins

2) Scales zero properly and record accurately

   a. Scale lever systems kept clean

   b. All scale lever rods, knife edges, etc. shielded where possible

3) Binder bucket tared properly

4) Aggregate weigh box hanging free

5) Mixer parts in good condition and adjusted, and proper size batch being mixed

6) Sufficient mixing time

7) Uniform binder and aggregate distribution in the pugmill

8) Valve and gate not leaking

9) Proper aggregate and binder temperature when these materials are introduced into the weighing receptacles

10) Screens are not worn or damaged

11) Moisture content of aggregate is within requirements after leaving the dryer

12) All proper safety requirements being met

Automatic Control Panel Inspection Items

At plants where an automatic control panel is used, the following items are required to be added to the Technician's check-list:

1) Input or formula data correct

2) Bin withdraw order in proper sequence

3) Automatic switch in "on" position

4) Mix timers correctly set

5) All control switches in correct position

When a plant uses an automatic recording device, the Technician is required to check the following items regularly:

1) Printouts check accurately against material input and scales

2) Aggregate printout refers to proper bins

3) Printout readings remain continuous

DRUM PLANTS

Drum mixing is a relatively simple process of producing HMA. The mixing drum from which this type of plant obtains the drum mixing name is very similar in appearance to a batch plant dryer drum. The difference between drum mix plants (Figure 3-31) and batch plants is that in drum mix plants the aggregate is not only dried and heated within the drum, but also mixed with the binder. There are no gradation screens, hot bins, weigh hoppers, or pugmills in a drum mix plant. Aggregate gradation is controlled at the cold feed.

As the aggregates (correctly proportioned at the cold feed) are introduced into the drum mix plant for drying, the binder is also introduced into the drum. The rotation of the drum provides the mixing action that thoroughly blends the binder and the aggregates. As the HMA is discharged from the drum, the mixture is carried to a surge bin and subsequently loaded into trucks.

Figure 3-31. Typical Drum Mix Plant

DRUM MIX PLANT COMPONENTS

The fundamental components of the drum mix plant (Figure 3-32) are:

1) Aggregate cold-feed bins

2) Conveyor and aggregate weighing system

3) Drum mixer

4) Dust collection system

5) Hot mix conveyor

6) Mix surge bin

7) Control van

8) Binder storage tan

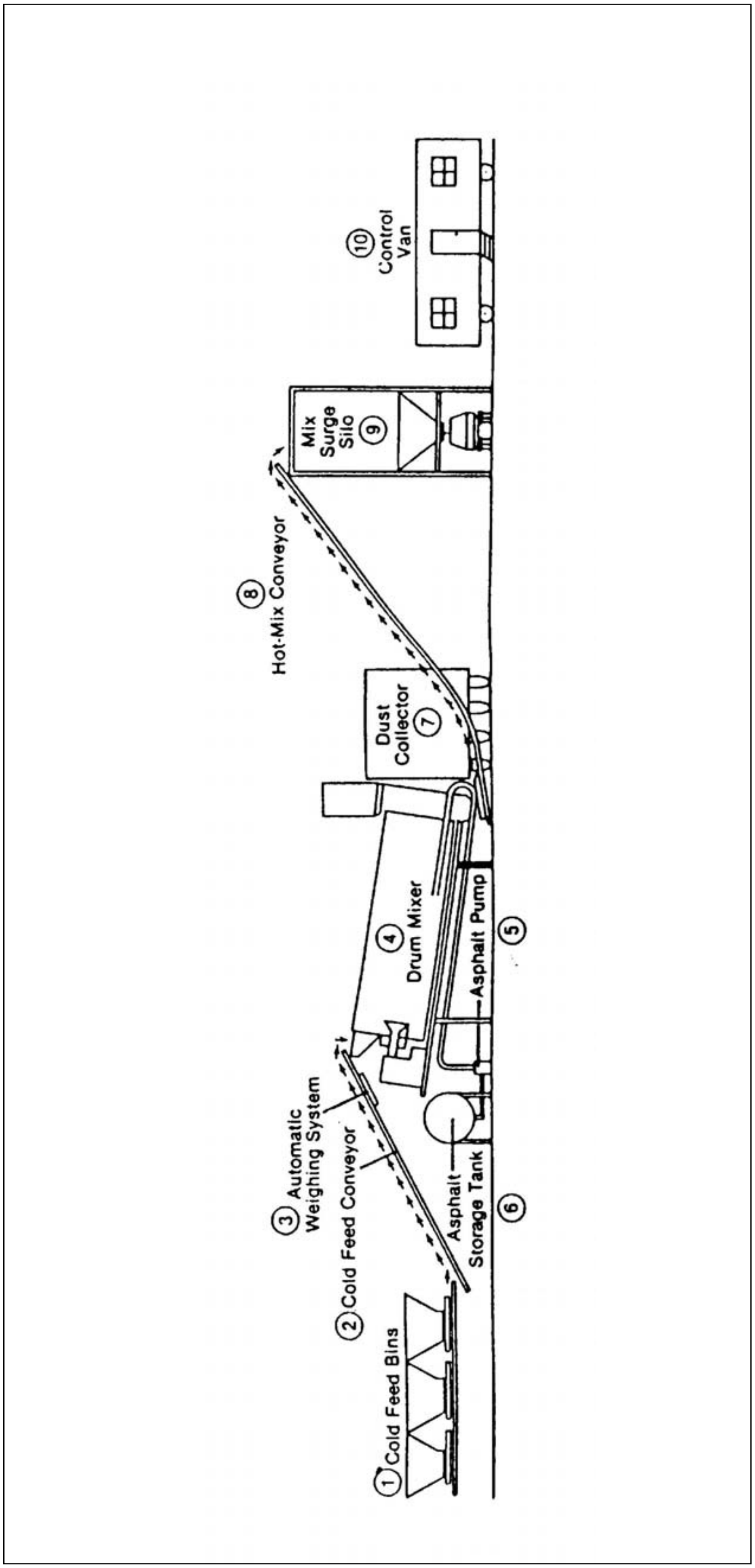

Figure 3-32. Basic Drum Mix Plant

Referring to Figure 1-32, the following is a brief, general description of the sequence of processes involved in a typical drum mix plant operation: controlled gradations of aggregates are deposited in the cold feed bins (1) from which the aggregates are fed in exact proportions onto a cold-feed conveyor (2). An automatic aggregate weighing system (3) monitors the amount of aggregate flowing into the drum mixer (4). The weighing system is interlocked with the controls on the binder storage pump (5), which draws binder from a storage tank (6) and introduces binder into the drum where binder and aggregate are thoroughly blended by the rotating action of the drum. A dust collection system (7) captures excess dust escaping from the drum. From the drum, the HMA is transported by hot mix conveyor (8) to a surge bin (9) from which the mixture is loaded into trucks and hauled to the paving site. All plant operations are monitored and controlled from instruments in the control van (10).

The mixing process is essentially similar in all drum mixing plants; however, there are several plant designs available. These include the counter-flow drum, which has the burner located near the outlet end of the drum, and the unitized counter-flow drum, which has an outer mixing drum that surrounds the dryer drum.

The production of HMA meeting contract Specifications is most easily done when the various parts and functions of the plant are in balance; that is, when all parts are properly coordinated to work together as a smooth working unit. Also essential for consistent and high quality HMA is uniform (uninterrupted) plant operation. Accurate proportioning of materials is entirely dependent on the uniform flow of those materials. Plant stops and starts adversely affect HMA quality.

To ensure balance and uniformity necessary to produce HMA to meet Specifications, the following control equipment is required:

1) Separate cold feed controls for each aggregate size

2) Interlocking controls of aggregate cold feed, binder delivery, and additive delivery to the drum

3) Automatic burner controls

4) A dust collector constructed to waste or return the material uniformly as directed

5) Sensors to measure temperature of the HMA at drum discharge

6) Gate controls on surge hopper

7) Moisture compensator

Controls and monitoring devices are usually housed in the control van, where there is good visibility of the entire operation.

AGGREGATE STORAGE AND FEED

In a drum mix plant, HMA gradation and uniformity are entirely dependent on the cold feed system. Proper care is required to be exercised not only in production of the aggregate, but also in storage. The Producer is required to provide for receiving and handling aggregates in such a way that there is no danger of contamination or intermingling. Among other things, this means providing clean surfaces on which to place the materials.

Stockpiles are required to be properly graded and contain different-sized fractions to properly control the gradation of the HMA. Practices vary with respect to the sizes of aggregates that are separated into different stockpiles; however, for well-graded mixes ranging from 1/2 to 1 in. maximum size, at least two stockpiles are recommended.

For mixes with greater than 1 in. maximum aggregate size, aggregates are required to be separated into three stockpiles. Without this stockpile separation, the aggregate may be difficult to maintain the proper gradation control.

Segregated stockpiles, if uncorrected prior to plant production, result in HMA gradation difficulties. Segregation may be prevented by constructing stockpiles in lifts not exceeding the height a loader may place the material and by removing aggregate from the upper areas of the stockpile, thereby minimizing sloughing of the side slopes. Regardless of the method of handling, all efforts are required to be directed at delivering the correct, uniformly-graded aggregate blend to the mixing plant.

Since the typical drum mix plant, unlike a batch plant, does not incorporate a gradation screening unit, the aggregate is required to be proportioned prior to entry into the mixing drum. The most efficient way to accomplish this is with a multiple-bin cold feed system equipped with precision belt feeders for the control of each aggregate. Under each bin is a belt feeder onto which the aggregate is proportioned. Precise controls (Figure 3-33) are used here to feed the exact proportions onto the belt.

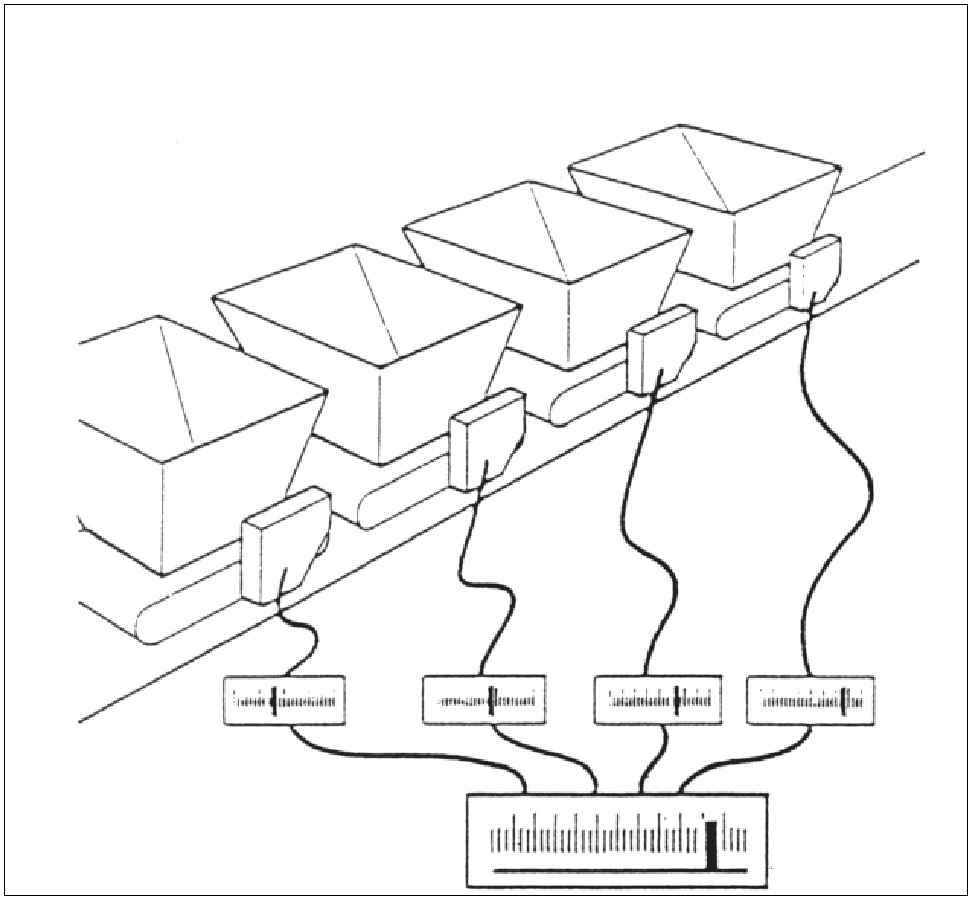

Figure 3-33. Master Cold Feed Contro

The plant is required to be equipped with provisions to obtain reprsentstive samples of the full fow of material from each cold feed and the total cold feed. The Technician is required to conduct a sieve analysis of the dried aggregate from these samples.

Cold feed control consists of the following:

1) Conduct a sieve analysis of the aggregate in each bin

2) Calibrate feeders - both gate opening and belt speed

3) Establish bin proportions

4) Set gate openings and be drive speeds

Once calibrated, the gate openings are required to be checked frequently to ensure the proper settings. All settings are considered temporary because the cold aggregate used in the mix may vary in gradation and moisture content, which may require adjustment of the gates or belt speed to maintain a uniform flow.

To calibrate the aggregate metering system and to plot a cold-feed control chart, a sampling device or method to obtain samples is necessary. The device is required to permit the flow of aggregate samples. Such devices are usually installed at the end of the conveyor belt just prior to entry into the drum mixer (Figure 3-34).

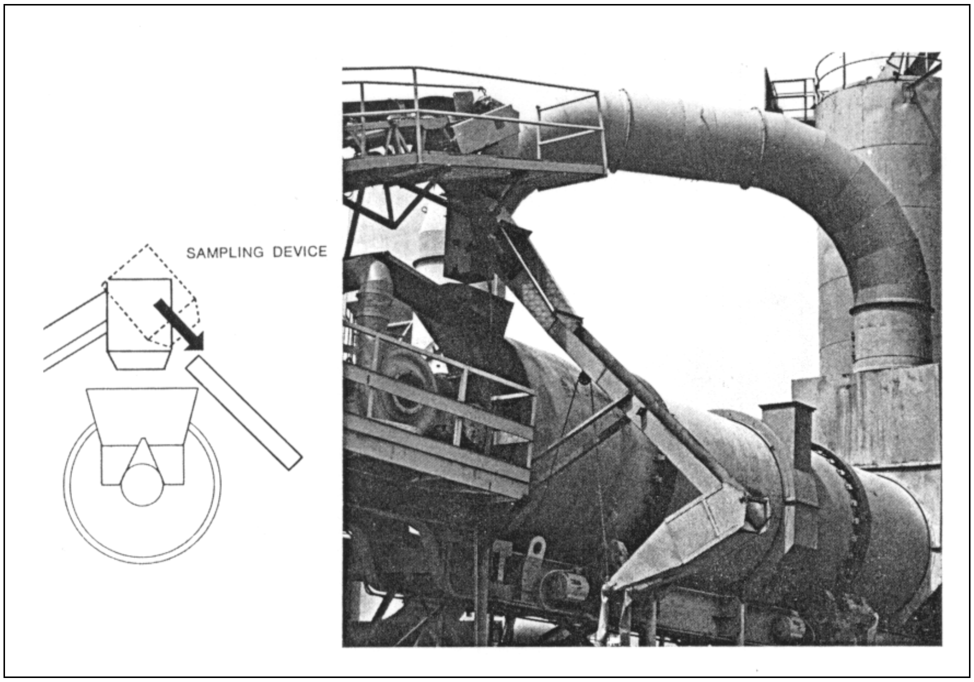

Figure 3-34. Typical Sampling Device

Drum mix plants require a continuous weighing system on the cold feed conveyor belts. In-line belt weighers, also called weigh bridges (Figure 3-35) are continuous belt-weighing devices used for this purpose. Combined aggregates passing over the conveyor belt are continuously weighed and a readout (in the control trailer) indicates the weight of the flow over the scale at any given instance. No material may be diverted from the conveyor belt after passing the belt weigher.

Figure 3-35 illustrates that one of the conveyor idlers (designated the weigh idler) of the belt weigher is mounted on a pivoted scale carriage. As the loaded belt passes over this idler, the weight is read in tons per hour and a reading is displayed at the control console in the control van or trailer. This reading is normally corrected to account for moisture in the aggregate (since dry-aggregate data is used to establish the required percentage of binder) and is a key reading in monitoring plant operations.

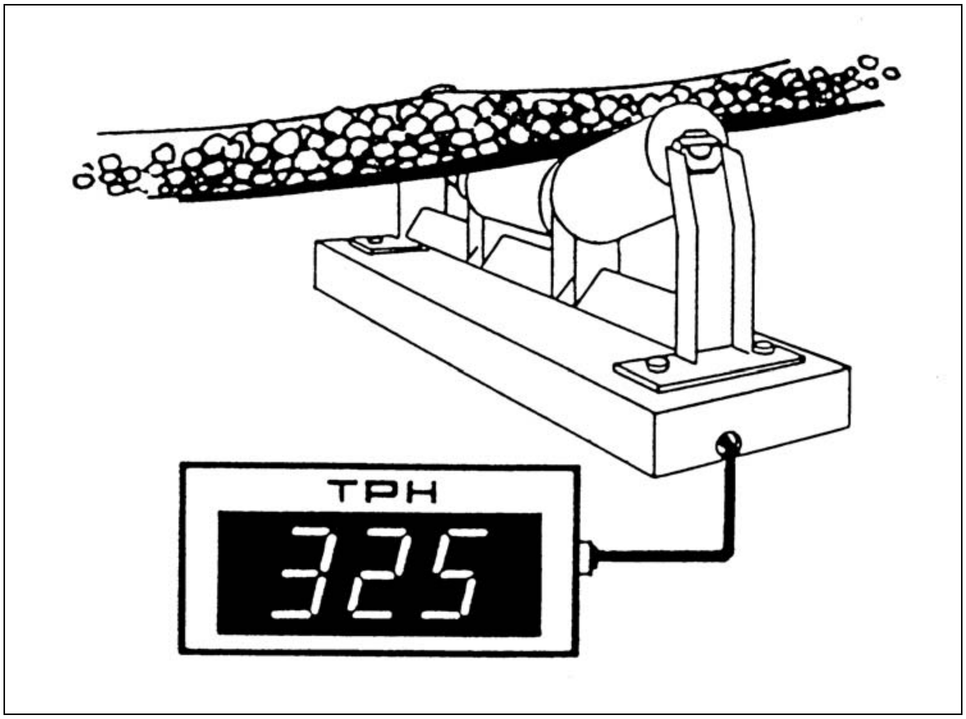

Figure 3-35. Typical In-Line Belt Weigher

The in-line belt weigher is usually located midway between the head and tail pulley of the cold feed belt conveyor. This location tends to lessen variations in reading caused by impact loading, roll-back of aggregate, or changes in belt tension. Means may be provided for conveniently diverting aggregates into trucks, front-end loaders, or other containers for checking the accuracy of the belt weigher. The device is required to be within ± 0.5 percent when tested for accuracy.

In drum mix plants the aggregate is weighed before drying. Since the undried material may contain an appreciable amount of moisture that may influence the aggregate weight, an accurate measurement of aggregate moisture content is important. From the measurement, adjustments may be made to the automatic binder metering system to ensure that the amount of binder delivered to the drum is proper for the amount of aggregate minus the aggregate moisture content.

The Technician is required to monitor the moisture content of the cold feed aggregate before beginning each day of operation and again about the middle of the day, and adjust the moisture control equipment accordingly. If the moisture content is believed to vary during the day, the aggregate is required to be checked more frequently. Provisions are required to be made for electronically correcting wet aggregate weight readings to dry aggregate weight readings.

BINDER METERING

The drum mixer is typically equipped with a device (Figure 3-36) to add binder to the aggregate inside the drum mixer. The binder metering and delivery system is a continuous mechanical proportioning system interlocked with the aggregate weight system to ensure an accurate binder content of the HMA. The weight of aggregate going into the mixer, as measured by the weigh belt, is the basis for determining the quantity of binder delivered into the drum.

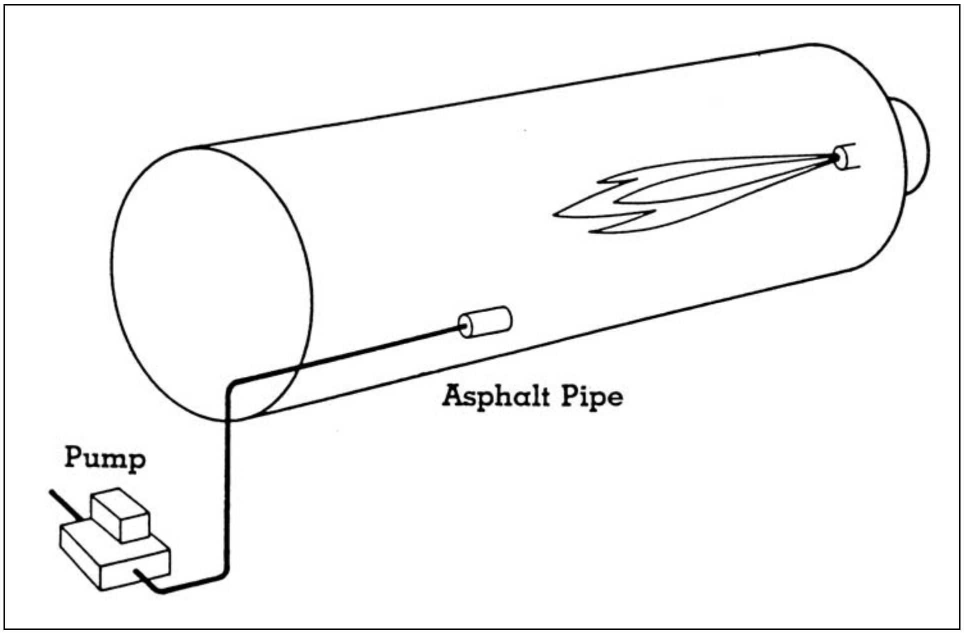

Figure 3-36. Binder Inlet

The proportioning of binder is accomplished by establishing the necessary rate of binder delivery in gallons per minute to match the aggregate delivery in tons of dry aggregate per hour. The binder delivery rate is increased or decreased proportionately according to the corrected dry weight measurement of aggregate passing over the belt scale. The rate of binder delivery is indicated on a rate meter on the control panel.

The rates of delivery of aggregate and binder are sometimes recorded on continuously recording circular graphs located in the control van. The graphs provide both monitoring and a permanent record of the proportioning of binder and total aggregate.

AGGREGATE MOISTURE DETERMINATION

Since aggregate in a drum mix operation is weighed before drying, moisture content of the aggregate is required to be determined. The weighing of aggregate and the metering of binder are interlocked electronically in drum mix operations. To ensure proper metering of binder, adjustments for aggregate moisture are made. The moisture content of the aggregate is required to be properly determined prior to the start of mixing and subsequently thereafter as changes occur in the condition of the aggregate.

To determine the moisture content of aggregate, a representative sample is required. As a general rule, representative samples are easier to obtain from storage bins or stockpiles. When the sample is taken from the conveyor belt, the aggregate is required to be removed from the entire cross-section of the belt. The size of the sample taken is determined by the maximum particle size of the aggregate.

Regardless of the size of the aggregate, the procedure (**AASHTO T 255**) for making an aggregate moisture determination is basically the same. The steps for this procedure are outlined as follows.

1) Obtain a representative sample of the material for the production

2) Reduce the sample to a size that may be handled by the weighing device by either a sample splitter or the quartering method

3) Weigh the aggregate sample and record the weight (Wet Weight)

4) Dry the aggregate sample thoroughly. The sample is dried to constant weight on a hot plate or in an oven at a temperature of 230° F.

5) Accurately weigh the dried sample and record the weight (Dry Weight). In weighing and handling the sample, extreme care is required to be taken to avoid any loss of the material, as this affects the accuracy of the results.

The percent moisture is determined by the following formula:

$$\% \text{ Moisture} = \frac{\text{Wet Weight - Dry Weight}}{\text{Dry Weight}} \times 100$$

Example

Wet Weight = 1225 g
Dry Weight = 1175 g

$$\% \text{ Moisture} = \frac{1225 - 1175}{1175} \times 100 = 4.3\ \%$$

DRUM MIX OPERATION

The heart of the drum mix plant is the mixer. The mixer is similar in design and construction to a conventional batch plant rotary dryer, except that a drum mixer not only dries aggregate but also blends the aggregate and binder together into the HMA.

The drum mixer may be divided into two sections or zones: a primary or radiation zone, and a secondary or convection/coating zone (Figure 3-37).

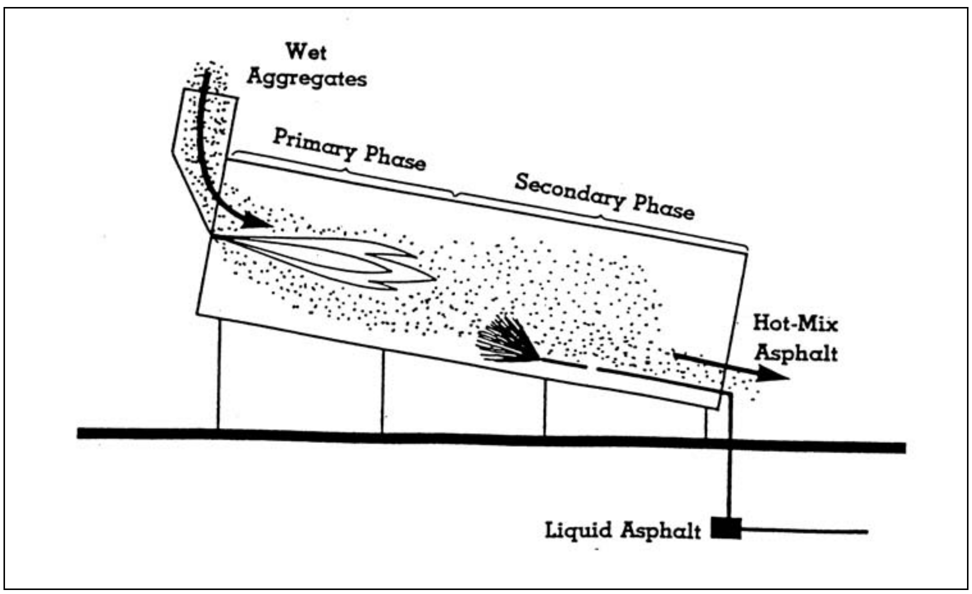

Figure 3-37. Zones in Drum Mixer

Aggregates enter the primary zone, where heat from the burner dries and heats them. The aggregate continues to the secondary zone, where binder is added and aggregates and binder are thoroughly blended. Continued convection drying also occurs in the secondary zone. The mixture of hot binder and moisture released from the aggregate produces a foaming mass that traps the fine material (dust) and aids in the coating of the larger particles.

Within the drum, the aggregate not only rotates with the revolving motion of the drum but also spreads out sufficiently to make heating and drying of all particles quick and efficient. To direct the aggregate flow and spread the aggregates into a veil across the cross-section of the drum, drum mixers are equipped with flights.

Spiral flights, located at the charging (burner) end of the drum, direct wet aggregate into the drum in such a way as to attain uniform drum loading. Tapered lifting flights then pick up the aggregates and drop them in an even veil through the burner flame. Subsequent flights direct the aggregate through the drum and continue to drop the material in veils through the cross-section of the drum.

Mix temperature is monitored continuously by a sensing device at the discharge end of the drum mixer. The temperature recorder and other indicators are located in the control van along with the burner controls.

A suitable means is required to be provided for inspecting and sampling the mixture after the discharge from the drum.

Burner Operation and Control

The purpose of the burner inside the drum mixer is to provide the heat necessary to heat and dry the aggregates used in the final mix. The burners provide this heat by burning oil, gas, or both.

When oil is burned, low pressure air drafts are used to atomize the fuel oil for burning. Burners using natural gas and LPG may be low-pressure or high-pressure units. In all cases, the fuel feed and air blower are required to be balanced to ensure that the proper proportions of fuel and air are being introduced into the burner for efficient combustion. Lack of balance may lead to incomplete burning of the fuel, which, especially in the case of fuel oil or diesel fuel, may leave an oily coating on the aggregate particles. Such imbalances between fuel feed and air flow may be corrected by either decreasing the fuel feed rate or increasing the blower or draft air.

SURGE BIN AND WEIGH SCALES

In a drum mixer operation, which produces a continuous flow of HMA, the plant is required to have a surge bin for temporary storage of the material and for controlled loading of trucks. A weigh system may be connected to the holding bin of the surge bin to monitor the amount of material loaded into each truck. Weight measurements are normally recorded by the weigh system control panel, located in the control van or trailer.

SUMMARY OF DRUM MIXERS

Close control of aggregate gradation in the cold bins, and the control of aggregate and binder feeding into the drum mixer are essential in providing uniform HMA using a drum mix plant. Drum mix plant inspection procedures are required to be followed to ensure that materials are proportioned correctly and properly mixed at the desired temperature. These procedures include inspecting the proportioning equipment, sampling and testing the aggregate gradation, determining aggregate moisture content, and monitoring HMA temperature.

EFFECT OF PLANT TYPE ON HMA PROPERTIES

HMA properties may vary depending on the type of plant and the environmental controls on the plant. The reason for these changes may be explained by how the plants function. Each plant/environmental control combination and the mix properties affected are discussed as follows.

BATCH/WET WASH

Because the aggregate is dried separately from the mixing chamber in a batch plant and the wet wash removes these fines, the mix tends to be higher in air voids and VMA.

BATCH/BAGHOUSE

Batch plant baghouses may return all or a portion of the fines back to the mix, or waste the fines. The air voids and VMA of mix produced by this combination may be varied to a great extent.

DRUM/WET WASH

In a drum plant, the aggregate drying and mixing chamber are located within the drum. Many of the fines being carried to the dust collection system are captured in the binder veil. This reduces the loading on the environmental equipment. If a wet wash system is used, then any fines that get past the binder veil are removed from the HMA. The amount of fines removed depends on a number of factors. The greatest factor is the total length of the drum and the length of the drum used for mixing. As both increase, less fines will enter into the environmental collection system.

The environmental controls in the drum/wet wash combination have less to do with the HMA properties. HMA produced from these plants are generally lower in Air Voids and VMA than Batch/Wet Wash combinations.

DRUM/BAGHOUSE

If a baghouse is utilized in a drum plant, the fines that are returned to the drum are added near the binder inlet. This is done so that the fines are immediately wetted and captured in the HMA. HMA produced by Drum/Baghouse combinations tend to be lower in Air Voids and VMA than other plant combinations.

AGGREGATE BLENDING

A HMA pavement requires more than binder, aggregate, and equipment. A good operation also requires knowledge, skill, and workmanship. Part of this knowledge and skill is the ability to blend aggregates to maintain the job mix formula.

A common problem in HMA construction is combining two or more aggregates with different gradations, to produce an aggregate blend that meets gradation specifications for a particular HMA. As previously stated, all particles required in the HMA are not usually found in one single aggregate. The HMA is made by blending different aggregate sizes together to meet the gradation requirements for the specified type of HMA.

DESIGN MIX FORMULA

In the simplest form, a design mix formula consists of two parts:

1) The combined gradation of the aggregates to be used in the production of HMA

2) The binder content necessary to produce a satisfactory HMA meeting all the Specification requirements

METHOD FOR COMBINING AGGREGATES

Sophisticated mathematical procedures have been developed that determine an optimum combination of aggregates. Computer programs are also available to facilitate this process. Although these procedures and programs are available, the Trial and Error Method, guided by a certain amount of reasoning, remains one of the easiest procedures to determine a satisfactory combination.

TRIAL AND ERROR METHOD

The proportions of each of the aggregates to be used in a HMA are required to be determined to produce a combined gradation that meets the required Specifications. The "Trial and Error Method" is the method that is shown for combining the aggregates. First, each of the steps is discussed and then applied to an example problem.

Step 1 -- OBTAIN THE REQUIRED DATA

1) The gradation of each material is required to be determined.

2) The design limits for the type of mix are required to be obtained. (Section **400**) Enter this information on the worksheet.

3) Select a target value for the combined gradation. Normally, this value is the percentage passing the No. 8 sieve. For example, the design limits for 25.0 mm Base mixture for the No. 8 sieve are 19.0-45.0. The combined gradation is required to be checked on this sieve first to verify that this value is within 19.0-45.0.

Step 2 -- ESTIMATE THE PROPORTIONS

After the target value has been selected, the next step is to estimate the correct percentage of each aggregate needed to get a combined gradation near the target value. For example, if two aggregates are combined, a possible combination may be 30% of Aggregate 1 and 70% of Aggregate 2.

Step 3 -- CALCULATE THE INDIVIDUAL PROPORTIONS

This calculation determines the percentage of each aggregate for the HMA. On the form, the "% for Mix" is obtained by multiplying the "Percent Used" (as a decimal) by the "% Passing" value.

Step 4 -- CALCULATE THE COMBINED GRADATION

This calculation indicates the results of the estimate from STEP 2. The method of calculating the combined gradation is shown in the example problem.

Step 5 -- COMPARE THE RESULTS WITH THE TARGET VALUE

If the calculated gradation is close to the target value, the problem has been solved; if not, an adjustment in the proportions is required to be made and the calculation conducted again. The second trial should be closer due to the information obtained from the first trial. The trials are continued until proportions of each aggregate are found that come close to the target value. If the aggregates do not combine within the design range, then another material of a different gradation is required to be added to the blend.

<u>Example (Combination of Two Aggregates)</u>

An example problem using two aggregates is shown in Figures 3-38 and 3-39. The No. 5 stone is designated Aggregate 1 and the No. 24 sand is designated Aggregate 2. The target gradation is for a 25.0 mm base mixture.

Step 1 -- Enter the known data:

1) percent passing from the gradation of each aggregate component

2) target specification for 1 in. base HMA

Step 2 -- Estimate the proportions. How much of each of the two aggregates are needed to produce a combined gradation close to the target value. (trial blend #1).

The first estimate might be 50% of Aggregate 1 and 50% of Aggregate 2. The proportions of each aggregate used are required to total 100%. Enter these figures on the line marked "Percent Used".

Step 3 -- Calculate the individual proportions on each sieve for each of the two aggregates and enter in the column "% for Mix". This is done by multiplying "% Passing" column by "Percent Used" (as a decimal). A sample calculation is shown at the bottom of Figure 3-38.

Step 4 -- Calculate the combined gradation. Add the two "% of Mix" columns horizontally for each sieve and enter in the column "Combined Gradation %".

SUPERPAVE AGGREGATE BLEND WORKSHEET

DATE: 7/1/2002
CONTRACT: R-22110
MIXTURE: 25.0 mm

Trial Blend #1

MATERIAL	#5 Stone		#24 Sand										
SOURCE	2211		2284										
Gsb	2.610		2.625										
PERCENT USED	50%		50%										
SIEVES	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	COMB. GRAD. %	DMF %	SPEC. LIMITS
1 1/2 in.	100	50.0	100	50.0							100		100
1 in.	93.2	46.6	100	50.0							96.6		90-100
3/4 in.	71.4	35.7	100	50.0							85.7		
1/2 in.	37.9	19.0	100	50.0							69.0		
3/8 in.	23.3	11.7	100	50.0							61.7		
No. 4	7.4	3.7	99.0	49.5							53.2		≤39.5
No. 8	4.7	2.4	70.4	35.2							37.6		19.0-26.8
No. 16	3.9	2.0	50.0	25.0							27.0		≤18.1
No. 30	3.2	1.6	32.9	16.5							18.1		≤13.6
No. 50	2.9	1.5	14.4	7.2							8.7		≤11.4
No. 100	2.2	1.1	3.5	1.8							2.0		
No. 200	1.6	0.8	1.5	0.8							1.6		1.0-7.0
PAN													

EXAMPLE: No. 8 Sieve 4.7 x .50 = 2.4%

Figure 3-38

SUPERPAVE AGGREGATE BLEND WORKSHEET

DATE: 7/1/2002
CONTRACT: R-22110
MIXTURE: 25.0 mm

Trial Blend #2

MATERIAL	#5 Stone		#24 Sand										
SOURCE	2211		2284										
Gsb	2.610		2.625										
PERCENT USED	70%		30%										
SIEVES	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	COMB. GRAD. %	DMF %	SPEC. LIMITS
1 1/2 in.	100	70.0	100	30.0							100		100
1 in.	93.2	65.2	100	30.0							95.2		90-100
3/4 in.	71.4	50.0	100	30.0							80.0		
1/2 in.	37.9	26.5	100	30.0							56.5		
3/8 in.	23.3	16.3	100	30.0							46.3		
No. 4	7.4	5.2	99.0	29.7							34.9		≤39.5
No. 8	4.7	3.3	70.4	21.1							24.4		19.0-26.8
No. 16	3.9	2.7	50.0	15.0							17.7		≤18.1
No. 30	3.2	2.2	32.9	9.9							12.1		≤13.6
No. 50	2.9	2.0	14.4	4.3							6.3		≤11.4
No. 100	2.2	1.5	3.5	1.0							2.5		
No. 200	1.6	1.1	1.5	0.4							1.5		1.0-7.0
PAN													

EXAMPLE: No. 8 Sieve 4.7 x .70 = 3.3

Figure 3-39

Step 5 -- Compare this combined gradation with the Specification Limits %. Note that the combined gradation is not very close to the Specification Limits and is on the fine side. An adjustment is required to be made. For a trial blend #2, increase Aggregate 1 to 70% and lower Aggregate 2 to 30% as shown in Figure 3-39.

Since this combined gradation is within the Specification Limits, the desired results have been obtained.

Example (Combination of More than Two Aggregates)

The same basic steps are followed when combining more than two aggregates. (Figure 3-40).

TROUBLESHOOTING HINTS

Once the blend has been completed, the results are plotted on a 0.45 power gradation chart. For example, take a look at the blend in Figure 3-41. The No. 8 sieve is right on target and all the other sieves are within specification limits. Is this a good mixture?

Plot the blend on the 0.45 power chart (Figure 3-42). Notice that although the HMA does indeed comply with the Specifications, there is a severe dip on the 1/2 in. and 3/8 in. sieves. The HMA may be susceptible to segregation.

This HMA cannot be improved with available materials. The easiest procedure would be to add some minus 1/2 in. material. Take a look at Figure 3-43 and Figure 3-44. Notice that the addition of No. 11 stone improves the dip in the gradation band resulting in a HMA far less likely to segregate.

All problems are not this easy to correct; however, by plotting the blends, potential troublesome HMA may be spotted.

PLANT INSPECTION AND SCALE CHECK

All plants which produce HMA for INDOT are required to be inspected prior to becoming a Certified HMA Plant, annually thereafter, and when the plant is moved. This inspection verifies that all meters, scales, and other measuring devices are calibrated to an accuracy within 0.5% throughout their range.

Form TD-523 is used for the plant inspection. This form is required to be maintained at the plant and is reviewed during the HMA audit of the Certified Plant.

SUPERPAVE AGGREGATE BLEND WORKSHEET

DATE: 7/1/2002
CONTRACT: R-22110
MIXTURE: 25.0 mm

MATERIAL	#5 Stone		#11 Stone		# 24 Sand								
SOURCE	2211		2211		2284								
Gsb	2.160		2.610		2.628								
PERCENT USED	55%		15%		30%								
SIEVES	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	COMB. GRAD. %	DMF %	SPEC. LIMITS
1 1/2 in.	100	55.0	100	15.0	100	30.0					100		100
1 in.	93.2	51.3	100	15.0	100	30.0					96.3		90-100
3/4 in.	71.4	39.3	100	15.0	100	30.0					84.3		
1/2 in.	37.9	20.8	100	15.0	100	30.0					65.8		
3/8 in.	23.3	12.8	85.9	12.9	100	30.0					55.7		
No. 4	7.4	4.1	15.1	2.3	99.0	29.7					36.1		≤39.5
No. 8	4.7	2.6	3.0	0.5	70.4	21.1					24.2		19.0-26.8
No. 16	3.9	2.1	2.1	0.3	50.0	15.0					17.4		≤18.1
No. 30	3.2	1.8	1.8	0.3	32.9	9.9					12.0		≤13.6
No. 50	2.9	1.6	1.5	0.2	14.4	4.3					6.1		≤11.4
No. 100	2.2	1.2	1.3	0.2	3.5	1.1					2.5		
No. 200	1.6	0.9	1.0	0.2	1.5	0.5					1.6		1.5-7.0
PAN													

Figure 3-40

SUPERPAVE AGGREGATE BLEND WORKSHEET

DATE: 7/1/2002
CONTRACT: R-22110
MIXTURE: 25.0 mm

Mix #1

MATERIAL	#5 Stone		#24 Sand								COMB. GRAD. %	DMF %	SPEC. LIMITS
SOURCE	2211		2284										
Gsb	2.610		2.625										
PERCENT USED	75%		25%										
SIEVES	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX			
1 1/2 in.	100	75.0	100	25.0							100		100
1 in.	93.2	69.9	100	25.0							94.9		90-100
3/4 in.	71.4	53.6	100	25.0							78.6		
1/2 in.	37.9	28.4	100	25.0							53.4		
3/8 in.	17.5	13.1	100	25.0							38.1		
No. 4	7.4	5.6	99.4	24.9							30.5		≤39.5
No. 8	4.7	3.5	77.9	19.5							23.0		19.0-26.8
No. 16	3.9	2.9	59.7	14.9							17.8		≤18.1
No. 30	3.2	2.4	41.1	10.3							12.7		≤13.6
No. 50	2.9	2.2	15.5	3.9							6.1		≤11.4
No. 100	2.2	1.7	5.3	1.3							3.0		
No. 200	1.6	1.2	2.0	0.5							1.7		1.0-7.0
PAN													

Figure 3-41

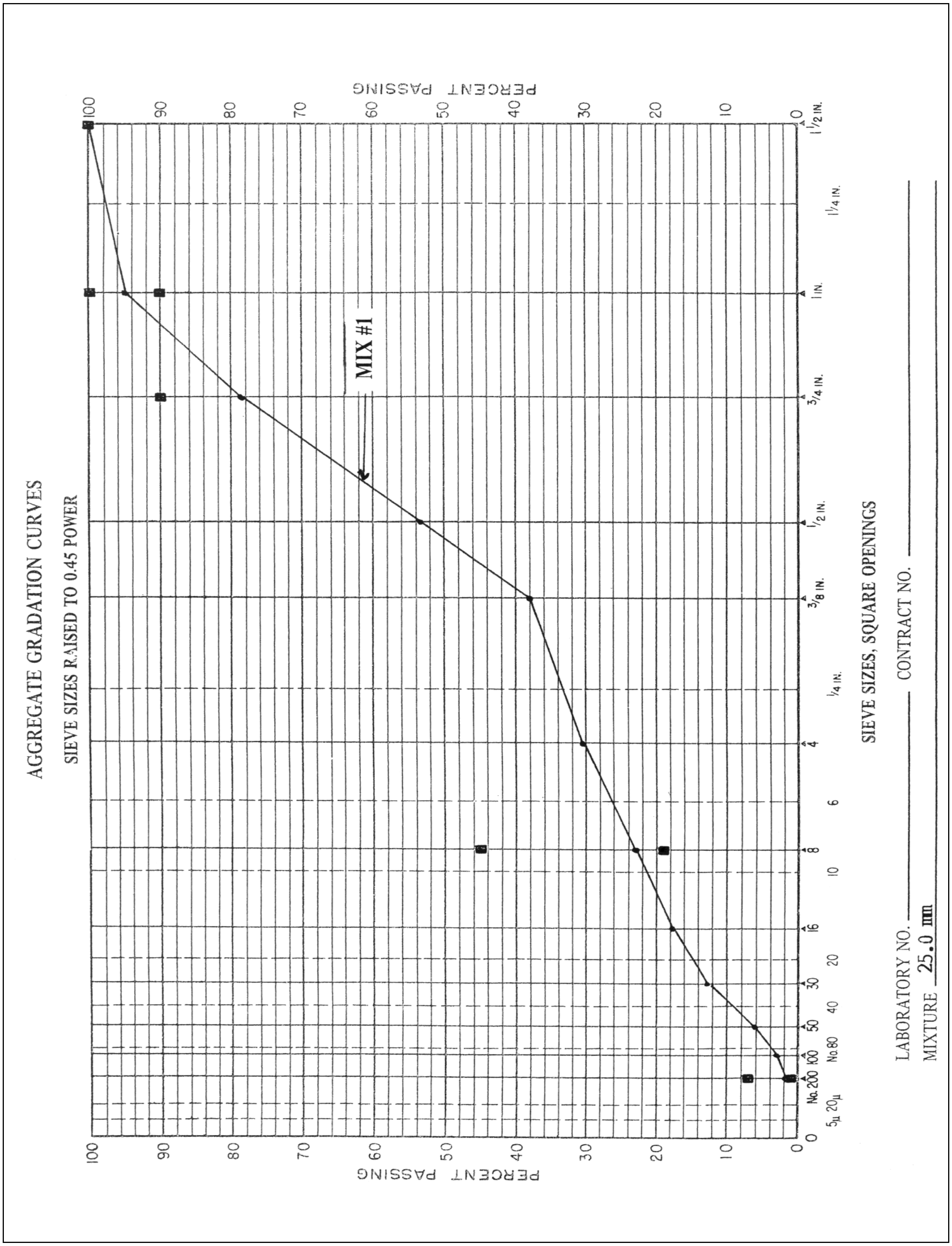
AGGREGATE GRADATION CURVES
SIEVE SIZES RAISED TO 0.45 POWER
PERCENT PASSING
MIX #1
SIEVE SIZES, SQUARE OPENINGS
LABORATORY NO.
CONTRACT NO.
MIXTURE 25.0 mm
1 1/2 IN.
1 1/4 IN.
1 IN.
3/4 IN.
1/2 IN.
3/8 IN.
1/4 IN.
4
6
8
10
16
20
30
40
50
No. 80
100
No. 200
5μ 20μ

Figure 3-42

SUPERPAVE AGGREGATE BLEND WORKSHEET

DATE: 7/1/2002
CONTRACT: R-22110
MIXTURE: 25.0 mm

Mix #2

MATERIAL	#5 Stone		#11 Stone		#24 Sand								
SOURCE	2211		2211		2284								
Gsb	2.160		2.610		2.625								
PERCENT USED	65%		11%		24%								
SIEVES	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	COMB. GRAD. %	DMF %	SPEC. LIMITS
1 1/2 in.	100	65.0	100	11.0	100	24.0					100		100
1 in.	93.2	60.6	100	11.0	100	24.0					95.6		90-100
3/4 in.	71.4	46.4	100	11.0	100	24.0					81.4		
1/2 in.	37.9	24.6	100	11.0	100	24.0					59.6		
3/8 in.	17.5	11.4	85.9	9.4	100	24.0					44.8		
No. 4	7.4	4.8	15.1	1.7	99.4	23.9					30.4		≤39.5
No. 8	4.7	3.1	3.0	0.3	77.9	18.7					22.1		19.0-26.8
No. 16	3.9	2.5	2.1	0.2	59.7	14.3					17.0		≤18.1
No. 30	3.2	2.1	1.8	0.2	41.1	9.9					12.2		≤13.6
No. 50	2.9	1.9	1.5	0.2	15.5	3.7					5.8		≤11.4
No. 100	2.2	1.4	1.3	0.1	5.3	1.3					2.8		
No. 200	1.6	1.0	1.0	0.1	2.0	0.5					1.6		1.0-7.0
PAN													

Figure 3-43

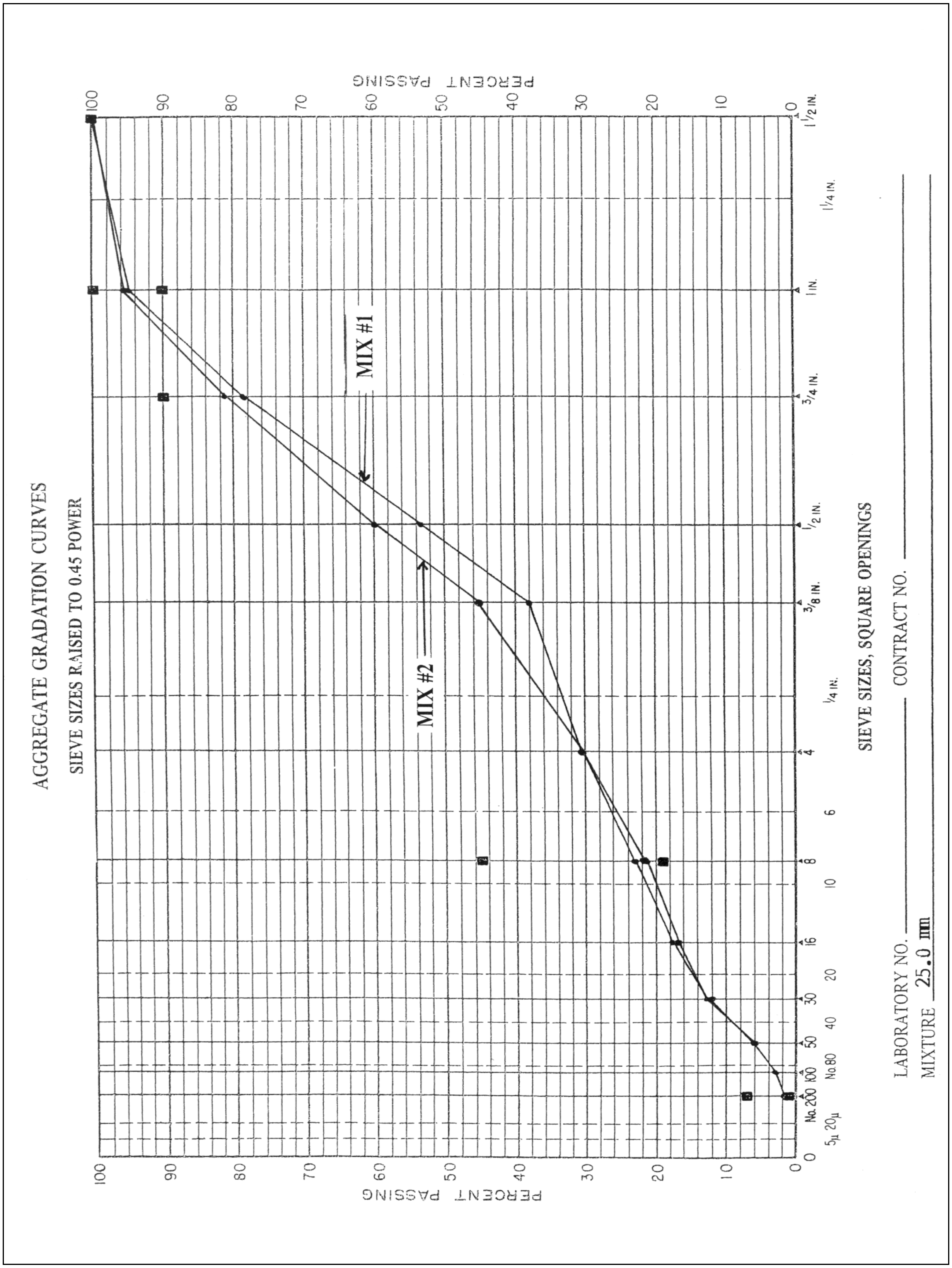
AGGREGATE GRADATION CURVES
SIEVE SIZES RAISED TO 0.45 POWER
MIX #1
MIX #2
PERCENT PASSING
SIEVE SIZES, SQUARE OPENINGS
LABORATORY NO.
CONTRACT NO.
MIXTURE 25.0 mm

Figure 3-44

BATCH PLANT

For a batch plant, all scales are checked starting at zero and extending up through the production range. At least ten 50 lb weights for testing the scales are required to be available at the plant. Therefore, 50 to 500 lb is the normal increment check. If a private scale company is available, 1000 lb increments may be used. Typically at least five different readings throughout the range for each scale are checked. The accuracy required is 0.5 percent error.

If a meter for measuring the amount of binder is used, then gallons are required to to be converted to weight. A distributor is typically used for this check. This method requires at least three checks in the normal working range to an accuracy of 0.5 percent.

When a fines return system is used, the measuring system is checked in the working range to an accuracy of 0.5 percent. A graph of Control Setting vs Flow Range is required to enable the plant operator to accurately control the fines returning into the mix.

DRUM PLANT

The load cells and binder supply system are checked for accuracy on a drum plant. Since HMA proportioning for a drum plant is done by a moving weight system, the computer monitors are required to be checked for accuracy. (Figure 3-46)

The load cell on each aggregate belt is required to be checked. This check is done by running material across the load cell into a tared truck. The computer inventory is required to match the actual weight by 0.5 percent. This check is required to meet accuracy requirements three consecutive times. A truck load of material is used for each check to obtain better accuracy.

The binder system check uses a tared distributor that is required to check against the pump reading on the flow meter and the computer monitor. These units are required to match the weight in the distributor by 0.5 percent accuracy. Whether the pump and/or the computer are temperature compensating is required to be checked. The agreement is required to match the 0.5 percent accuracy three consecutive times and be in the working range of the plant.

The fines return system is required to also be checked to 0.5 percent accuracy as is done with a batch plant.

State Form 42371 (3-88)
TD-523

INDIANA DEPARTMENT OF TRANSPORTATION
MATERIALS AND TESTS DIVISION

Date 6-30-01

INSPECTION OF SCALES AND METERS FOR BATCH AND DRUM PLANT

Producer McKinney, Inc. Plant Location Terre Haute, IN Number 3001

Scales and Meter shall be checked to the maximum capacity for which they will be used. The allowable difference between the scale reading and the actual weight applied shall be 0.5% or less. Meter variation shall also be 0.5% or less.

BATCH PLANT
Aggregate Scales

Make Wayne Serial No. 48507 Dial Capacity 10,000 lb

Load Applied	500	1000	2000	3000	4000	5000			
Scale Reading	500	1000	2010	3010	4010	5020			
Error lbs.	0	0	10	10	10	20			
% Error	0	0	0.50	0.33	0.25	0.40			

Bitumen Measuring System

Make Wayne Serial No. 976FM6 Dial Capacity 1000 lb

No. Gallons									
Load Applied	50	100	200	300	400	500	600	700	
Scale Reading	50	100	201	301	401	501	602	702	
Error lbs.	0	0	0	1	1	1	2	2	
% Error	0	0	0.50	0.33	0.25	0.20	0.33	0.29	

Fine Return System

Make Wen Serial No. 27543 Dial Capacity 500 lb

Load Applied	50	100	150	200	250	300	350	400	
Scale Reading	50	100	150	201	251	301	351	402	
Error lbs.	0	0	0	1	1	1	1	2	
% Error	0	0	0	0.50	0.40	0.33	0.29	0.50	

Signature ______________________

Figure 3-45

Date 8-7-01

Producer R-Paving Inc. Plant Location Reddington, IN Number 9999

Scales and Meter shall be checked to the maximum capacity for which they will be used. The allowable difference between the scale reading and the actual weight applied shall be 0.5% or less. Meter variation shall also be 0.5% or less.

DRUM PLANT

COLD AGGREGATE FEED SYSTEM (Belt Scale Check) Main Belt & Recycle Belt

Gross Weight	Tare Weight	Net Weight	Gross Comp.	Tare Comp.	Net Comp.	% Error
43280	21000	22280	22260	0	22260	0.09
43240	21000	22240	44490	22310	22180	0.27
43250	21000	22250	64370	42180	22190	0.27

ASPHALT METER CHECK

Gross Weight	Tare Weight	Net Weight	Computer Weight	% Error	Meter Gallons	Meter Weight	% Error
31100	28560	2540	2530	0.39			
33700	31120	2580	2570	0.39			
36280	33720	2560	2565	0.20			

Conversion Factor: Temp. Corr. Factor x Weight @ 60F

Fines Return System

Make Wayne Serial No. 410 R 1 Dial Capacity 500 lb

Load Applied	50	100	150	200	250	300	350	400	
Scale Reading	50	100	150	200	249	299	349	399	
Error lbs.	0	0	0	0	1	1	1	1	
% Error	0	0	0	0	0.40	0.33	0.29	0.25	

Signature____________________

Figure 3-46

PLANT CALIBRATION

BATCH PLANT

For a uniform output from the plant, input is required to be accurately measured. The exact amount of each size aggregate is required to be fed to the dryer at the correct rate of flow (cold feed calibration on IT 667). The cold feed calibration prevents shortages or over-loading of individual hot bins. Also, uniform feed from the cold bins prevent possible moisture or temperature fluctuations. When the cold feeds are calibrated, the batch plant is ready to be calibrated.

Form IT 665 is used to assist Batch Plant Operators in determining the batch weight. This procedure is required before initial production is started. Batch weight percents are used to complete form IT-651A. The following steps are required to be used to complete the batch plant calibration.

1) Fill out the first four lines of form IT 665 with the information pertaining to the HMA to be produced. (Figure 3-47)

2) The compartments of the cold aggregate feed bins are filled with the proper size of approved coarse and fine aggregate. The feeders are set to deliver the proportions of the required HMA, as determined by the cold feed calibration.

3) The plant is started to dry and screen the aggregate, with the plant running at normal production rates, until the hot bins are approximately one-half of their capacity.

4) Weigh the entire contents of Bin No. 4, retain at least a 20 lb sample for later analysis, and place the total amount weighed in the appropriate space of Bin Analysis.

5) Repeat the procedure for Bins 2 and 3

6) Bin No. 1 is required to contain only sand. A sample is taken for gradation analysis but the content weight need not be recorded since the fine aggregate proportions are usually changed in the cold feeder.

7) Calculate the percent that bins 2, 3, and 4 contribute to the coarse aggregate, Lines E, F, and G.

8) Sieve the samples from Bins 1, 2, 3, and 4 to determine the amount retained on the No. 4 screen. Form IT 651 is used for the gradation. Record this data on Form IT-665, Lines P, R, S, and J.

9) Complete the form to obtain the total percentage and weight of aggregate to be taken for each batch from Bins No. 1, 2, 3, and 4 by inserting the recorded amounts identified by capital letters into the formula and making the calculation. The capital letters are explained on page 3-70.

10) The weight pulled from each bin is designated by the letters W, X, Y, and Z. This information is needed by the plant operator to assure the correct mix gradation.

11) The batch weight percentages may be used on form IT 651 to obtain the final gradation of the blend of aggregates.

State Form 7842 (R/1-89)
FORM IT-665

INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS
Bin Proportions and Batch Weights (Batch Type Plants)

Date 7/14/01

Producer ABC Asphalt Co. Plant No. ____ Contract No. RS-21234

Type of Mix 25.0 mm Bit. Content A 4.5 % Pass No. 4 B 27 %

Total Batch Wt. = C 5000 lbs. Ret. No. 4 D 73 %

Screen Opening Size Over - Bin 1 ______ Bin 2 ______ Bin 3 ______ Bin 4 ______

BIN ANALYSIS (Carry decimal to thousandth)

Bin No.	Agg. Wt. Lbs.	% of V (as a decimal)		(From IT-651A) % Ret. No. 4		Ret. No. 4 of V
4	6100	E 0. 343	x	P 100 %	=	34.3 %
3	8200	F 0. 461	x	R 95 %	=	43.8 %
2	3500	G 0. 196	x	S 92 %	=	18.0 %
Totals	V 17800	1.000				H 96.1 %

Percent Retained on No. 4 Screen in Bin No. 1 = J 4.0 %

Total Agg. Wt. = $\frac{100\% - A}{100}$ = 0. 955 x C 5000 Lbs. = K 4775 Lbs.

Total % & Amount Taken From Bins 2, 3 & 4

$\left(\frac{D\,73.0\ \%}{H\,96.1\ \%}\right) - \left(J\ 0.041 \times B\ 0.270\right)$ = L 0.749 x K 4775 Lbs. = M 3576 Lbs.

Bin No. 1 = 1.000 − L 0. 749 = N 0. 251

					Batch Weights		(as a decimal)	=		
Bin 4	E 0.343	x	M 3576	=	W 1227 Lbs.	x	P 1.000	=	1227 Lbs.	Ret #4
Bin 3	F 0.461	x	M 3576	=	X 1649 Lbs.	x	R 0.950	=	1567 Lbs.	Ret #4
Bin 2	G 0.196	x	M 3576	=	Y 701 Lbs.	x	S 0.920	=	645 Lbs.	Ret #4
Bin 1	N 0.251	x	K 4775	=	Z 1199 Lbs.	x	J 0.040	=	48 Lbs.	Ret #4
Total Agg.					K 4776 Lbs.				T 3487 Lbs.	Total
Bit.	A 4.5 % x C 5000 / 100			=	225 Lbs.					
			Total Wt. C	=	5000 Lbs.					

$\frac{T\ 3487}{K\ 4776}$ x 100 = D 73 Check

Batch Weight %

Bin 4 **W** ÷ **K** x 100 = 25.7 %

Bin 3 **X** ÷ **K** x 100 = 34.5 %

Bin 2 **Y** ÷ **K** x 100 = 14.7 %

Bin 1 **Z** ÷ **K** x 100 = 25.1 %

Total 100.0%

Use these bin percents on IT-651A

____
Signature — Title

Figure 3-47

A. Percent of Binder (information from design mix formula).

B. Percent passing the No. 4 screen. (information from design).

C. Total batch weight of the plant.

D. Percent to be retained on the No. 4 screen. (100-B)

V. The total weight of aggregate in bins 2, 3, and 4.

E. Percent of the weight of aggregate contained in the No. 4 bin to the total aggregate weight contained in bins 2, 3, and 4.

F. Percent of the weight of aggregate contained in the No. 2 bin to the total aggregate weight contained in bins 2, 3, and 4.

G. Percent of the weight of aggregate contained in the No. 2 bin to the total aggregate weight contained in bins 2, 3, and 4.

P. Percent retained on the No. 4 screen in bin 4.

R. Percent retained on the No. 4 screen in bin 3.

S. Percent retained on the No. 4 screen in bin 2.

H. Total percent retained on the No. 4 screen in bins 2, 3, and 4.

J. Percent retained on the No. 4 screen in the No. 1 bin.

K. Total weight of aggregate in a batch.

L. Total percent of aggregate weight to be drawn from bins 2, 3, and 4 per batch.

M. Total weight of aggregate weight to be drawn from bins 2, 3, and 4 per batch.

N. Percent of aggregate weight to be drawn from the No. 1 bin per batch.

W. Batch weight (lbs) to be drawn from bin 4.

X. Batch weight (lbs) to be drawn from bin 3.

Y. Batch weight (lbs) to be drawn from bin 2.

Z. Batch weight (lbs) to be drawn from bin 1.

T. Total pounds of aggregate from bins 1, 2, 3, and 4 which are retained on the No. 4 screen.

DRUM PLANT

Each plant manufacturer has a somewhat different type of control panel for the cold aggregate feed system and binder metering system; however, all drum mixing plant aggregate and binder proportioning systems perform basically the same. Form IT 667 may be used to calibrate a drum plant. The entire calibration is required to be done at the same master control bin setting, which is recorded.

To calibrate a drum plant, each belt system with a load cell is checked: main collector belt, recycle belt, individual feeder belts, etc. To do a proper check, sufficient quantities of material to simulate normal production rates are passed over the load cell and into a tared truck. A beginning and ending computer inventory for the material is recorded and compared to the actual weight of the material in the truck. Three consecutive tests are required to be within 0.5 percent to ensure adequate accuracy. (Figure 3-46).

Once the load cells have been checked, the calibration of each individual bin flow rates may be determined. At least three different flow rates for each bin spanning the normal production rate are determined. This may be done using the computer monitor readings at various control settings. The recommended method is to use a tared truck on a timed interval, as described next and on Form IT-667. (Figure 3-48)

Step 1 -- Determine Control Setting vs Flow Rate

Each bin contains material to be used and the gate height is measured and recorded. The timed method runs material across the load cells at three different dial control settings for each individual bin. The material is run into a tared truck and weighed at each control setting. Therefore, for each bin used, the dial (control) setting, time in minutes, and weight in tons are known. The ton per hour may be calculated for each setting. (Figure 3-48, Step 1.)

Step 2 -- Plot Cold Feed Control Graph

From this data a Cold Feed Control Graph can be drawn for each bin which plots Flow Rate vs Control Setting. (Figure 3-49)

Step 3 -- Determine Plant Control Setting

The next step in the calibration is to use the Cold Feed Control Graph and the anticipated production rate at which the plant produces material to determine the Control Settings for each individual bin. (Figure 3-48, Step 3.)

First determine Total Aggregate Flow Rate by multiplying the desired Production Rate times the % of Aggregate in the HMA. Next multiply that Total Aggregate Flow Rate times the % which each Individual Bin contributes to the HMA to obtain the Flow Rate desired from each bin (Note: This % per bin is obtained from the mix design or is obtained by trial and error using IT-651A). Using the Cold Feed Control Graph (1) locate the Flow Rate for that bin, (2) move to the Control Line for that bin, and (3) move to the resulting Control Setting. Follow the procedure for all bins. The control settings are supplied to the plant operator to produce the required mixture.

Step 4 -- Check for Accuracy of Calibration

To ensure the proper gradation has been determined, a composite aggregate sample is obtained. Set the established individual Bin Control Settings and start the aggregate flow into the drier. When a uniform material flow is on the main belt, stop the operation.

In a safe manner completely remove 2 to 5 ft of material from the belt. Split this sample to proper sample size. Conduct a gradation test and compare the data to the design mix formula. If agreement is not obtained, investigate to determine the discrepancy.

IT-667

INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS

Drum Mix Plant Calibration

Contract RS-21111 Date 8-7-01

Producer R-Paving Plant Location Reddington, IN Number 9999

Type Mix 25.0 mm Coarse Agg. Source Harding, Inc.

Master Control Setting ________ (To remain at same setting while calibrating all bins)

Step I — Determine Control Setting vs. Flow Rate

COLD AGGREGATE BIN FEEDERS CALIBRATION

Bin No.	Agg. Size	Setting Gate	Setting Dial	Gross Weight	Tare Weight	Net Weight	Time Mins.	Pounds/ Minute	Tons/ Hour
3	5 St.	8 in.	2	70293	37560	32733	10	3273.3	98.2
3	5 St.	8 in.	4	60420	37560	22860	6	3810.0	114.3
3	5 St.	8 in.	6	63340	37560	25780	6	4296.7	128.9
3	5 St.	8 in.	8	64044	37560	26484	5	5296.8	158.9
2	12 St.	5 in.	2	41260	37560	3700	10	370.0	11.1
2	12 St.	5 in.	3	44027	37560	6467	10	646.7	19.4
2	12 St.	5 in.	4	48660	37560	11100	10	1110.0	33.3
2	12 St.	5 in.	5	55027	37560	17467	10	1746.7	52.4
1	24 Sd.	6 in.	2	45660	37560	8100	10	810	24.3
1	24 Sd.	6 in.	4	46360	37560	8800	6	1466.7	44.0
1	24 Sd.	6 in.	6	51200	37560	13640	6	2273.3	68.2
1	24 Sd.	6 in.	8	53894	37560	16334	5	3266.8	98.0

Step 2 — Plot "Cold Feed Control" Graph from above data.

Step 3 — Determine Plant Control Setting Bin.

— Mix Production rate x (100 – %bit) = T (total aggregate)

(100 – 4.5)

225 t/hr x 95.5% = (T) 214.9 t/hr

— Determine Flow Rate for each Cold Feed

Bin	Agg. Size	T	x	P	=	T* (per bin)	=	Bin Control Setting**
1	24	214.9	x	.25	=	T_1 53.7	=	47%
2	12	214.9	x	.15	=	T_2 32.2	=	39%
3	5	214.9	x	.60	=	T_3 128.9	=	60%
4			x		=	T_4	=	
5			x		=	T_5	=	

*TPH – T x P

lb/min = $\frac{T \times P \times 2000}{60}$

T = Agg. Production Rate

P = % of Aggregate for Bin from Form IT-651A or JMF

**From "Cold Feed Control" Graph

State Form 7844 (R2/12-88) Signature________________

Figure 3-48

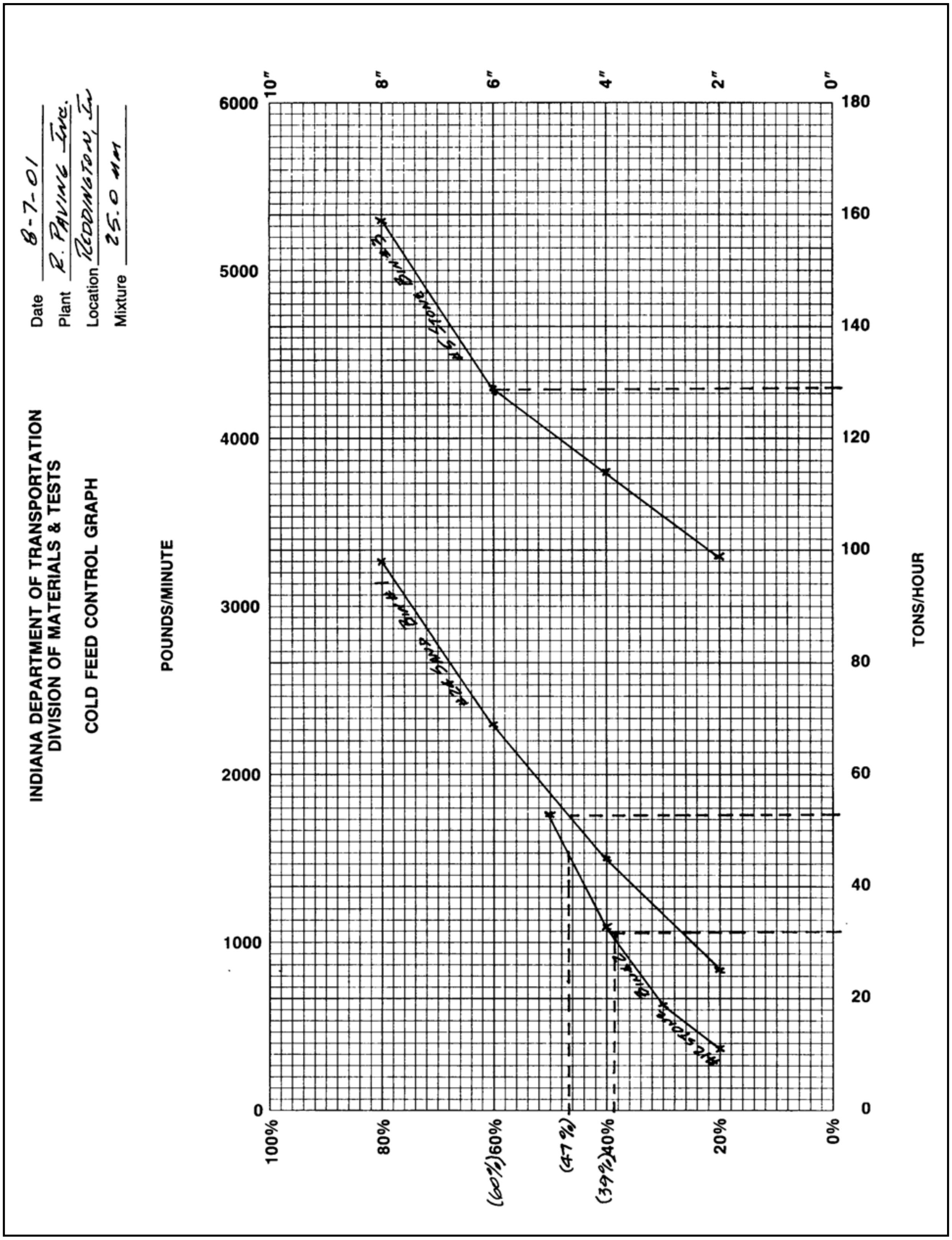
INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS & TESTS
COLD FEED CONTROL GRAPH
Date 8-7-01
Plant R. Paving Inc.
Location Reddington, In
Mixture 25.0 mm
POUNDS/MINUTE
TONS/HOUR
0
1000
2000
3000
4000
5000
6000
0
20
40
60
80
100
120
140
160
180
10"
8"
6"
4"
2"
0"
100%
80%
(60%) 60%
(47%)
(39%) 40%
20%
0%

Figure 3-49

PLANT TROUBLESHOOTING

Temperature control is stressed in all phases of HMA production, since this is a primary factor in controlling quality. A visual inspection may often detect whether or not the temperature of a load of HMA is within the proper range. Blue smoke rising from a truckload of HMA is often an indication of overheating. If the HMA temperature is too low, the HMA may appear sluggish when deposited in the truck and may show a non-uniform distribution of binder. An abnormally high peak in a truckload may also indicate underheating.

A high peak in the truckload may also be an indication that the binder content of the HMA is too low. On the other hand, if the HMA slumps (fails to peak properly) in the truck, the binder content may be too high or there may be excessive moisture.

There are many common causes of visible nonuniformity in HMA. Figure 3-50 is a handy reference which the Technician may use to identify problems in HMA and possible causes of these problems.

Types of Deficiencies That May Be Encountered In Producing Plant-Mix Paving Mixtures.	Aggregates Too Wet	Inadequate Bunker Separation	Aggregate Feed Gates Not Properly Set	Over-Rated Dryer Capacity	Dryer Set Too Steep	Improper Dryer Operation	Temp. Indicator Out of Adjustment	Aggregate Temperature Too High	Worn Out Screens	Faulty Screen Operation	Bin Overflows Not Functioning	Leaky Bins	Segregation of Aggregates in Bins	Carryover in Bins Due to Overloading Screens	Aggregate Scales Out of Adjustment	Improper Weighing	Feed of Mineral Filler Not Uniform	Insufficient Aggregates in Hot Bins	Improper Weighing Sequence	Insufficient Asphalt	Too Much Asphalt	Faulty Distribution of Asphalt to Aggregates	Asphalt Scales Out of Adjustment	Asphalt Meter Out of Adjustment	Undersize or Oversize Batch	Mixing Time Not Proper	Improperly Set or Worn Paddles	Faulty Dump Gate	Asphalt and Aggregate Feed Not Synchronized	Occasional Dust Shakedown in Bins	Irregular Plant Operation	Faulty Sampling
Asphalt Content Does Not Check Job Mix Formula			A												B	B				A	A	A	B	C	B	B	B		C			A
Aggregate Gradation Does Not Check Job Mix Formula		A	A						B	B	B	B	A	A	B	B	B	A							B		B	B	C	B		A
Excessive Fines in Mix		A	A							B	B	B	A	A	B	B	B	A							B	B			C	B		A
Uniform Temperatures Difficult to Maintain	A			A	A	A	A	A																							A	
Truck Weights Do Not Check Batch Weights												B			B	B									B							
Free Asphalt on Mix in Truck															B	B					A	A	B	C	B		B		C			
Free Dust on Mix in Truck																			B									B				
Large Aggregate Uncoated	A			A	A	A	A													A		A	B	C	B	B	B		C		A	
Mixture in Truck Not Uniform										B	B	A	A	A	B	B	B	A	B			A	B	C		B	B	B	C	B	A	
Mixture in Truck Fat on One Side																			B			A			B	B	B				A	
Mixture Flattens in Truck						A															A	A	B	C	B				C		A	
Mixture Burned			A			A	A	A																							A	
Mixture Too Brown or Gray	A			A	A	A	A			B										A			B	C	B				C		A	
Mixture Too Fat															B	B	B	A			A	A	B	C	B				C		A	
Mixture Smokes in Truck						A	A	A																							A	
Mixture Steams in Truck	A			A	A	A	A																								A	
Mixture Appears Dull in Truck						A	A	A												A										A	A	

Figure 3-50. Possible Causes of HMA Deficiencies.
A - Applies to Batch and Drum MixPlants
B - Applies to Batch Plants
C – Applies to Drum Mix Plants